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Inter-industry Differences in the Accounting Numbers
of U.K. - quoted Companies: A Multivariate Analysis

By

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Submitted for the degree of Doctor of Philosophy to
the City University, London.

The research was carried out at the City University
Business School, London.

May, 1981

To



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Acknowledgements

I am happy to record my grateful thanks to the many individuals from whom I received generous assistance in the course of my research. In particular, Dr. Richard Raffler as my supervisor readily helped me when my personal commitments threatened to thwart my embarking upon doctoral research. Subsequently in carrying out the research he willingly yielded to my frequent demands on his time and enthusiastically guided me through my research. The source of my initial inspiration was [REDACTED] whose enthusiasm for this undertaking often exceeded my own and sustained me through the vicissitudes of my research.

I wish to thank [REDACTED] of the University of Leeds for not only encouraging me in my effort but also allowing me, upon my appointment as Lecturer, time to complete the research. I have benefited from his perceptive comments on an earlier draft of this thesis as also from the suggestions of [REDACTED] [REDACTED] [REDACTED] [REDACTED] of the City University Business School, [REDACTED] [REDACTED] of Leeds University and the participants at a London School of Economics departmental seminar and at the Northern Accounting Group Conference at Liverpool University.

My thanks are also due to [REDACTED] [REDACTED], the Librarian at the City University Business School, [REDACTED] of City University computer advisory service and the advisory and operating staff at the University of London Computer Centre where I carried out almost all the computing work relating to this research.

I also wish to thank very deeply [REDACTED] and [REDACTED] for the encouragement and support they provided in the early stages of my research.

Declaration

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Abstract

Among the major extant issues in present day financial analysis is the use of the concept of industry as an analytical framework. Borrowed from the conventional microeconomic theories of the firm the industry concept has been used widely in financial analysis.

The use of the industry concept in financial analysis pre-supposes:

1) the descriptive ability of accounting numbers and 2) industry homogeneity under a given industrial classification system. The research design was to identify financial ratios which distinguished a) between manufacturing and distribution firms and b) among 14 manufacturing industries in a statistically significant and economically meaningful manner employing linear and quadratic discriminant analyses and the Stock Exchange Industrial Classification (SEIC) widely used in the City. The research results showed: 1) that accounting numbers had significant descriptive ability 2) that the manufacturing and distribution sectors were fairly homogeneous although there appeared to be systematic forward or backward integration in certain segments of the sectors and 3) that the manufacturing industries varied widely in terms of homogeneity. The systematic patterns of misclassifications among the 14 manufacturing industries suggested that aggregation of these basic industries on the basis of the observed misclassifications would result in more homogeneous groupings of firms. Accordingly 4- and then 3- group discriminant analyses were carried out. The "super-industry" groupings were more homogeneous and appeared to be justified in terms of similarity of technology, nature of production process etc, as well as in terms of significant narrow spectrum diversification among the basic industries within each super-industry. The results suggested that the criteria used in SEIC needed to be reformulated.

The study also examined both theoretically and empirically a number of other important issues bearing on financial statement analysis

which have not received much attention in the literature:

- 1) the assumptions and empirical validity of ratio transformation of raw accounting numbers.
- 2) the problem of spurious ratio correlation involving ratios with common deflators.
- 3) the distributional properties of financial ratios and
- 4) the dimensionality of accounting information (using principal components analysis).

Chapter 1

Objectives and Outline of the Study

1.0 Introduction

Although financial statement analysis had its inception in the second half of the last century its evolution has been haphazard. Whereas new and exciting vistas have opened in the fields of capital asset valuation, portfolio theory and the related areas of finance, financial statement analysis has lagged behind. As a result, it has remained alienated from economic and financial decision theories and the usefulness of financial statement information has been regarded with scepticism. Lev (1974) perceptively summarises the position thus:

".... financial statement analysis still remains in the initial stage of the development of a science. A large amount of data and numerous financial ratios are available yet the usefulness of the traditional tools and techniques has not been established." (p.4)

Until recently naive ad hocism and untested assumptions often disguised as "pragmatic empiricism"¹ characterised financial statement analysis (hereafter FSA). Although some of these assumptions have been rigorously tested by various researchers in the last few years² there are still many issues to be conclusively resolved. Among the major extant issues is the use of the concept of industry as an analytical framework. Although industry averages as bench marks for financial ratios have been used since about 1910³, the industry concept owes its popularity more to its importance in conventional microeconomic theories of the firm than to any explicitly established relationship between a

1. See Horrigan (1968, p. 264) from whom the phrase has been taken.

2. See Foster (1978) for an excellent coverage of the most relevant issues in FSA, and the related empirical work.

3. Lev (1974, p. 2).

firm's industry and its financial characteristics (i.e. accounting numbers)⁴. The legitimacy of the use of the industry concept is the main focus of the present study. Additionally, we examine some of the related issues concerning methods for assessing the usefulness of accounting numbers, the appropriateness of financial ratios as tools of FSA and the distributional properties of financial ratios. We believe that the empirical evidence we provide can help strengthen the conceptual and empirical foundations of FSA thereby enhancing the utility of financial statements to decision makers.

1.1. The Concept of Industry in Financial Statement Analysis and the Underlying Assumptions

1.1. 1 In present day FSA we may discern three different uses of the industry concept. Firstly, it is employed in an evaluative context where the aim is to measure the performance and financial condition of a firm. Evaluation implies judgment based on comparison with an appropriate standard and the most frequently used standard in FSA is the industry average or some alternative measure of central tendency such as the median⁵. The choice of industry average or median is based on the assumption that firms within an industry are homogeneous with respect to their financial characteristics. The assumption of homogeneity, however, is subject to criticism. Industrial classification of firms is based on criteria such as substitutability of products, technology of production etc. and these criteria have been found to be not wholly satisfactory⁶. The degree of homogeneity, therefore, depends on the criteria underlying the industrial classification system used by the financial analyst. Even where classification is based on well defined criteria, product diversification by firms might result in industry groupings becoming heterogeneous.

1.1. 2 Secondly, industry is regarded as an environment exogenously determined and capable of affecting the financial characteristics

4. Foster (1978, p. 61).

5. Lev, op. cit. This is also evidenced by such publications as Robert Morris Associates' "Annual Statement Studies", Dun & Bradstreet's "Key Business Ratios" in the USA and Dun & Bradstreet's "Management Ratios" in the UK. Inter Company Comparisons "Industrial Performance Analysis" is another example.

6. Foster, op. cit, Chapter 3. The problems of industry definition and the factors causing non-homogeneity of industries are discussed in Chapter 2.

of all the firms within it. This assumption underlies the use of industry indices alongside economy-wide indices as explanatory variables in regression models to explain or forecast the values of accounting variables of individual firms ⁷.

"Index models enable quantification of the effects of (economy-wide and industry-wide) factors. Such quantification can be important when assessing financial trends in a firm and when forecasting financial variables". (Foster, 1978, p. 155).

To consider industry as an exogenous variable is, however, not valid when firms are increasingly capable of altering their environment ⁸. Moreover, the exact functional relationships between industry characteristics and firms' accounting numbers are not yet known. As yet there is only limited theoretical and empirical analysis bearing on the relationship between accounting rates of return and industry characteristics ⁹. The functional relationships between industry characteristics and other accounting variables such as leverage remain to be explored ¹⁰.

- 1.1. 3 Thirdly, industry is regarded as encapsulating some of the less easily definable attributes of firms such as business risk. Firms within the same industry are assumed to be homogeneous with respect to their business risk which has an important place in the valuation of firms. Business risk relates to the risk inherent in the operations of the enterprise. Some companies are in highly volatile lines of endeavour while others are in stable lines. A machine tool company would fall in the former category while an electric utility would be in the latter ¹¹. The equivalence between industry class

7. See Foster, Chapter 5.

8. See Devine et al (1977). This assumption is discussed further in Chapter 2.

9. e.g. Stigler (1963), Cootner & Holland (1970) on profitability and industry risk and George (1974) on the relationship between profitability and concentration.

10. Some U.S. studies have analysed these relationships e.g. Gupta (1969, 1972) and Eugene (1977). These are discussed in greater detail in Chapter 4. To the knowledge of the author, there has been no U.K. study of a related nature.

11. See Brigham (1980), Chapter 15 on business risk.

and business risk forms one of the basic assumptions in Modigliani and Miller's hypothesis about the financial structure and cost of capital of firms:

"Certainly the basic characteristics of the probability distributions of the returns on assets will depend to a significant extent on the product sold and the technology used".
(1958, p. 458).

1.1. 4 The assumption that industry groupings represent equivalent business risk classes raises two fundamental issues - the appropriate definition of business risk and the homogeneity of industry groups in terms of that definition. Researchers have used both univariate and multivariate definitions of risk¹² but the results are not conclusive as regards the homogeneity condition. Falk and Heintz (1975, 1977) used accounting ratios as surrogates for industry risk but the selection of these ratios was not based on any demonstrable evidence or a priori reasons to support the view that they necessarily reflected or measured industry risk¹³. Moreover, it is not clear from their studies how far the industries in their sample are homogeneous with respect to the accounting variables used. For accounting variables to be surrogates for industry risk it is essential that they are able to:

- 1) reflect those specific industry characteristics which define business risk and
- 2) distinguish between industries with varying risk complexions.

1.1. 5 Our brief discussion of the issues associated with the use of the industry framework in FSA highlights the need firstly to establish the relationship between accounting numbers of firms and the characteristics of their industrial environment and then to assess the extent of homogeneity of industry groups in terms of financial statement variables. In other words it is necessary to identify those variables which are best able to discriminate among different industries and to study how far these discriminators reflect the underlying economic characteristics of the industries. This search

12. See Wipperfurth (1966), Gonedes (1969) and Rao (1972) for the univariate and Martin et al (1979) for the multivariate approach.

13. The authors themselves point to this lack of evidence (1977, p. 8).

for economically meaningful financial variables in respect of which industry groups are distinct and homogeneous delineates the broad scope of the present study.

1.1. 6 Identification of economically meaningful accounting numbers which distinguish among industries has an important bearing upon the question of usefulness of accounting statements. In the literature several criteria have been proposed to evaluate the usefulness of accounting numbers and hence of accounting statements. In Chapter 3 we discuss these criteria and their conceptual and operational limitations and argue that "descriptive ability" or the ability of accounting numbers to reflect the underlying economic characteristics of a firm such as its industry attributes, is the most appropriate criterion. The results of this study will be used to determine whether according to this criterion and its particular operational definition used in this study accounting numbers are useful or not.

1.2. Methodology of the Study

1.2. 1 Analysis of the informational content of financial statements may be performed in many different ways to allow both cross-sectional and inter-temporal comparisons¹⁴. However, financial ratios computed from accounting numbers are among the best known and the most widely used tools of financial analysis. In this study we use financial ratios as our data. Transformation of raw accounting numbers to ratios is most often intended to eliminate the effect of size thus facilitating comparison across firms of different sizes and of the same firm over time. The extent to which the elimination of the size effect is achieved by ratio transformation is rarely, if ever, tested in the financial ratio literature¹⁵. Ratio transformation often leads to ratios with common denominators (also called deflators). When two such ratios are related, as in a regression model, the presence of the common deflator has often given rise to the suspicion that the relationship between the two may be spurious¹⁶. Empirical studies of these and other issues¹⁷ related to the use of financial ratios are

14. See Foster (1978), Lev (1974) and Bernstein (1978) who discuss the various techniques of FSA.

15. See Lev & Sunder (1979).

16. See Gonedes (1973, p. 436).

17. These other issues are referred to in Paragraph 1.3.2. on next page.

lacking in the financial literature ¹⁸. In Chapter 5 we examine these very important issues and provide some empirical evidence bearing on them.

- 1.2. 2 Inter-industry differences in financial ratios are analysed using multiple group discriminant analysis (MDA) which is now a fairly well established technique in the financial literature ¹⁹. MDA is arguably the most appropriate technique given the objectives of our study since it seeks to identify "those variables which best discriminate between groups and which are most similar within groups" (Altman, 1973, pp.195-6). The various statistical issues concerning the use of MDA are discussed and our attempts at data modification to satisfy the assumptions of the technique are described in Chapter 5.
- 1.2. 3 An important consideration in the use of MDA is the choice between linear and quadratic classification rules. Theory dictates that this should depend on the degree of equality of the group dispersion matrices and that where they are unequal quadratic classification is appropriate. MDA studies reported in the literature have, with a few exceptions, used the linear rule without testing the assumption of dispersion equality ²⁰. The chief advantage of the linear rule lies in its ease of application and interpretation. While these are important considerations in applied research it is also important to establish that there is no undue loss of classificatory accuracy arising from the use of the inappropriate model. In this study, therefore, we shall test our data for conformity with the equality assumption and, where necessary, apply the quadratic model in addition to the linear so that the results from each may be compared. Such a comparison will shed light on the relative merits of the two rules and also provide some indication of the conditions under which either rule may be superior to the other. This study is believed to be the first in the finance area in the U.K. to use quadratic discriminant analysis.

18. Lev & Sunder (1979) provide some empirical evidence concerning the proportionality between net income and average total assets which is an assumption of ratio transformation. Apart from this there has been very little empirical work reported in the literature.

19. For an extensive list of studies using MDA in the USA see Eisenbeis (1977). In the U.K. Taffler (1977) is an example of the use of this technique.

20. See Eisenbeis (1977) for a review of these studies.

1.3. Objectives of the Study

1.3. 1 We have already laid out the broad issues to be examined by this study. The following are our specific objectives:

- 1) to test the hypothesis that firms in different industries have different financial characteristics represented by their accounting numbers
- 2) to test the hypothesis that accounting numbers of firms have significant descriptive ability for the purpose of reflecting the underlying economic characteristics of their respective industries
- 3) to test the hypothesis that industry groups are stable over time in terms of their distinct financial characteristics and
- 4) to study whether aggregation of basic industries yields more homogeneous groups as regards their distinct financial features.

1.3. 2 As indicated in the previous section, we also examine some of the methodological issues relating to financial ratios and financial statement analysis in general. Specifically, we shall test the following hypotheses:

- 1) that ratio components are homogeneously and linearly related
- 2) that ratio transformation with common deflators leads to spurious correlation and
- 3) that ratios are normally distributed.

We shall also present the results of a principal components analysis (PCA) ²¹ of our data. This analysis was carried out to assess the inter-correlations among the ratios and their dimensionality. Our results will demonstrate that accounting information can be parsimoniously represented by a small number of distinct and independent dimensions without significant loss of information. The application of (PCA) assists both in the selection and interpretation of ratios in our discriminant models. The general implications of our (PCA) results for practical financial ratio analysis are taken up in Chapter 6.

21. PCA is described briefly in Appendix 6.1. For further reference see Child (1976), Rummel (1970) and Harman (1976).

1.4. Outline of the Thesis

- 1.4. 1 The conceptual framework of the present study is provided in the next chapter which discusses the problems both in the definition of "industry" and in the construction of industrial classification systems. It also discusses the sources of inter-industry differences in the financial characteristics of firms drawing upon the prevalent theoretical and empirical framework of industrial economics. Factors which tend to obscure or obliterate inter-industry differences are also examined. Chapter 3 discusses the issues relating to the usefulness of financial statements and the different criteria proposed in the literature to assess it. A fresh approach to the evaluation of financial statements is suggested. Chapter 4 surveys the literature we will be drawing on in subsequent chapters and discusses the scope and methodology of the present study in contra-distinction to the previous research.
- 1.4. 2 Chapter 5 deals with the data and the related issues including conformity with the statistical assumptions of the models subsequently employed, and describes the data modifications undertaken to achieve such conformity. Chapter 6, as noted in Paragraph 1.3. 2, presents the PCA results together with their implications. The results of the discriminant analysis between manufacturing and distribution sectors for 6 years are presented in Chapter 7. The results are analysed with a view to testing the hypotheses set out in Paragraph 1.3. 1. Ratios which best discriminate between the two sectors are identified and their economic meaning investigated. Chapter 8 presents the results of the discriminant analysis of 14 conventional industries over 6 years. The results provide additional tests of our hypotheses. The economic meaning of the discriminant ratios is investigated in order to assess their descriptive ability.
- 1.4. 3 Classification matrices are examined to assess the extent of homogeneity of each industry based on the rate of correct classification. Misclassifications are investigated in order to identify systematic patterns of cross-industry affinity among industries. The reasons for systematic misclassification are investigated. Where this can be explained by relevant industrial and economic factors, the industries concerned can be logically regarded as forming one

homogeneous group. Based on this approach the 14 industries are aggregated into initially 4 and then 3 super-industries. Discriminant analysis of the new groups is reported in Chapter 9. We examine whether the empirical aggregation into 3 super-industries is founded in industrial logic and provides a superior alternative to the conventional industrial classification. Chapter 10 summarises the results of our analysis and discusses the implications.

Chapter 2

Inter-industry Differences in Economic Characteristics

2.0. Introduction

The fundamental hypothesis of this thesis is that there are inter-industry differences in the accounting numbers of firms and that these are related to the substantive economic characteristics of the industries in question. According to economic theory¹ the industrial environment of firms is an important determinant of their financial behaviour, performance and condition and firms within the same industry are homogeneous with respect to their substantive attributes while differing from firms in other industries. Our hypothesis is based on the expectation that the substantive inter-industry differences will be reflected in the observed accounting numbers. This, however, depends on the ability of the accounting process employed to record with fidelity the underlying substantive attributes of firms. The relationship among the observed accounting numbers, the substantive economic attributes and the descriptive ability of the accounting process is set forth in the next section.

The descriptive ability issue is dealt with in the next chapter from the perspective of accounting theory. In the present chapter we examine the postulate that industry influences the financial characteristics of firms within the framework of a three-factor model. The problems of industry definition and classification are considered and the reasons for choosing the Stock Exchange Industrial Classification (SEIC) for the purpose of our study are stated. We then describe the mechanism by which industry-related factors affect the financial characteristics of firms.

2.1. Economic Determinants of Differences in the Financial Characteristics of Firms - A Three Factor Model

2.1.1 The three factor model shown in Figure 2.1. divides the influences on

1. See Devine et al (1979).

the financial characteristics of firms into three broad categories:

- 1) economy-wide factors
- 2) industry-wide factors and
- 3) firm-specific factors.

Business firms operate in an environment which is uncertain and continually changing. The environmental changes, however, are varied in their origin and nature as well as their impact. Some events such as government monetary, fiscal and taxation policies affect all the firms in the economy whereas changes in a particular technological area will affect only those firms whose market is threatened by the possibility of cheaper or better alternative products being produced by the new technology. Moreover, governmental policy on monopolies and price control may be directed towards certain industries.

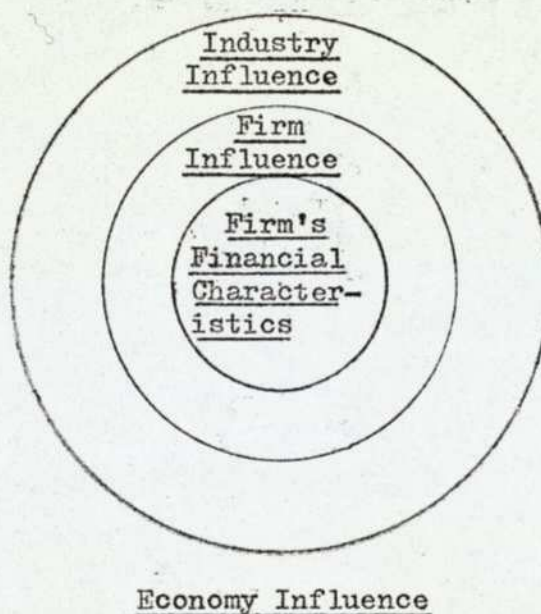


Figure 2.1. : Determinants of the Financial Characteristics of Firms: Three Factor Model

- 2.1. 2 Given a set of economy-wide or industry-wide events at a particular point in time, firms in the same industry or market will respond to these events in different ways. Their response is a function of their adaptational needs and abilities.

"Adaptive behaviour is not merely passive behaviour of the stimulus-response kind. It includes aggressive adaptation taking advantage of the resources and opportunities available to the firm by imaginative and innovatory action".
(Chambers, 1967, p. 25).

Adaptive behaviour may take place even in the absence of any changes in the environment involving, e.g. a change of strategy or alteration of the internal organisational structure in order to achieve some pre-determined goal such as increased market share. Every change in the firm whether self-initiated or in response to external events has implications for its financial structure and performance. For example, pursuance of a policy of reduced reliance on borrowed funds will change the firm's leverage and presumably affect its rate of return on investment.

- 2.1. 3 In the three factor model industry is a significant part of the environment interposed between the firm and the overall economy. However, unlike the economy or the firm industry is an artifact of the economist in theory and the statistician in practice. The validity of the industry framework depends crucially upon the particular industrial classification used. The problems of industry definition and of the criteria to be used in classifying firms into industries form the subject of the next section.

2.2. Industrial Classification Systems

- 2.2. 1 Although in our study we have chosen to analyse interfirm differences within the framework of "industry" it is necessary to examine the related framework of "market" which plays a central role in conventional microeconomic theory. In many empirical studies of the behaviour of firms "industry" is often used as a synonym for "market". Typically, seller concentration which is fundamentally a market concept has been studied using Standard Industrial Classification data (Nightingale , 1978). Yet, industry and market are coterminous only in the context of an undifferentiated or single product, perfect competition market model ².

2. See Devine et al (1979), Chapter 1.

2.2. 2 Within the perfect competition model, firms in the same industry all produce a single identical product which they sell in the same market. Therefore, industry and market are effectively identical since each contains the same group of firms either as producers or sellers. However, in more realistic markets comprising large multi-product firms

"each industry as conventionally understood, produces a range of different products many of which are close substitutes and which are sold in a variety of different markets". (Devine et al, 1979, p.11).

This tendency is derived from the versatile nature of contemporary technology which permits products for the same end use to be produced in many materials (e.g. cotton and synthetic fibre in the case of garments) and also leads to the production of new products or the creation of new uses for old products (e.g. petroleum-based chemicals and fertilisers).

2.2. 3 An alternative definition of market that takes into account the prevalence of product differentiation is based on the mutual substitutability of the differentiated products measured by their cross-elasticity.

"Where cross-elasticity is high and positive product substitutability should also be high, and such products may be regarded as belonging to the same market". (Devine et al, 1979, p.47).

The products sold in a market may be produced by firms in different industries using different materials and different techniques. Nightingale (1978) cites the example of timber and steel trusses. However cross-elasticity is very difficult to define and measure in practice and its usefulness as a criterion for market definition is, therefore, very limited ³.

2.2. 4 If market has defied a neat definition under imperfect market conditions industry has proved no less intractable. Andrews (quoted by Nightingale, 1978 p. 32) defined an industry as

3. See Devine et al (1979, p. 47).

"any grouping of individual businesses, which is relevant when we study the behaviour of any one such business"

and described the chief characteristic of any industry as

"largely a matter of technique and process; an individual business must be conceived as operating within an "industry" which consists of all businesses which operate processes of a sufficiently similar kind (which implies the possession of substantially similar technical resources) and possessing sufficiently similar backgrounds of experience and knowledge so that each of them could produce the particular commodity under consideration and would do so if it were sufficiently attractive".

2.2. 5 Edwards and Townsend's definition (1962, p 75), that an "industry is generally an area which can be demarcated by the specialised knowledge and resources required by those who work in it" is broadly in harmony with Andrew's description of the chief characteristic of industry but quite different from his definition of it. Indeed, Nightingale (1978) argues that his chief characteristic and definition may often be in conflict or mutually exclusive. He endorses Brunner's (1975) suggestion that Andrew's chief characteristic be taken as the definition of industry but within a given planning horizon. The longer the time horizon the greater the chances of mobility of firms from one product line to another technologically similar line.

2.2. 6 While market and industry are not equivalent concepts or frameworks for a given analytical objective they are nevertheless not mutually exclusive entities. Firms' behaviour will be constrained by the conditions prevailing in the markets in which they sell their products and in the industries to which they, by virtue of technological affinity, belong. Thus, for example, seller or buyer concentration which is a market characteristic will influence the behaviour and performance of firms operating in that market. Similarly, innovative activity of firms is probably influenced by the technological state of the industry.

2.2. 7 The definitional problems we have so far discussed have considerably hampered the construction of industrial classification systems. This has been additionally hampered by measurement and data collection problems. The resulting inadequacies of industrial classification systems have been detailed by many authors. Indeed every discussion

of industrial structure opens with the all too familiar caveat about these inadequacies ⁴. They are traceable to both the vagueness of the criteria used in assigning firms to different industry classes and the insufficiency of data about the activities of those firms. The British Standard Industrial Classification (SIC) used the three criteria spelled out in the following statement which accompanied the 1968 classification ⁵:-

"The classification has been prepared to conform with the organisation and structure of industry and trade as it exists within the U.K. All relevant factors such as the commodity produced or services given, the raw materials used and the nature of the process or the work done have been taken into consideration".

2.2. 8 The input-process-output criteria used in the SIC in the U.K. are much broader than Andrew's chief characteristic referred to earlier (paragraph 2.2.4.). However, as we also noted above there is no unique relationship between input, process and output (see paragraph 2.2.2.). There is, therefore, "no reason why these criteria should coincide in their definition of an industry" ⁶. Moreover, the classification is based on the establishment as the unit of account and, therefore, depends upon the availability of separate accounts for each establishment. Where accounts for two or more establishments are integrated the establishments will be treated as one thus obscuring the true extent of diversification of the firm. Similarly, if the firm has several establishments producing different products it may be assigned to more than one SIC industry. (Devine et al, 1979, p. 28-29).

4. See Devine et al (1979) for a discussion of these issues.

5. The SIC system in the U.K. is a two tier system consisting of 1) Orders and 2) Minimum List Headings (MLH). These are also referred to as 2-digit and 3-digit industries (Utton, 1977). In the 1968 SIC there are 27 Orders and 181 MLH's. Each Order consists of a group of related Minimum List industries which are more disaggregated than the Orders. See Central Statistical Office (1968), Para. 4.

6. See Devine et al (1979), pp.28-29.

2.2.9 Since the unit of account in the SIC is the establishment a firm is not explicitly assigned to any industry. Since in financial analysis we are concerned with the financial characteristics of the firm per se each firm needs to be assigned to an industry. The SIC is, therefore, clearly inappropriate for the purpose of this study. The classification system used in this study which assigns an industry code to each firm is the one designed by the Faculty and the Institute of Actuaries for the London Stock Exchange. For this reason each firm's industry code is referred to as the Stock Exchange Industry Classification (SEIC) code. The industry groups used by the Financial Times in the construction of stock price indices are based on the SEIC but represent a more aggregated level ⁷.

2.2.10 The SEIC is more aggregated than the Minimum List Headings but less so than the Orders ⁸. This classification is widely used by analysts in the City. According to Pain (1980, p. 28) the FT Actuaries Index is

"widely adopted by all valuation and portfolio management services and partly because of this has a clear influence on the way investment research organisations are structured in the City".

2.2.11 Since SEIC uses the firm as the basic unit it is clearly advantageous to use it for the purpose of this research. But the SEIC is heir to the same imperfections as the SIC, probably more so because of the diverse nature of the activities of many firms and the arbitrariness in assigning them to a particular industry class. The SEIC being designed to meet the practical needs of the investment community in the U.K. is based on less rigorously defined criteria than the SIC. Indeed it is partly classification by committee ⁹. The SEIC was developed in 1970 and was modelled on the existing FT Actuaries Index of 650 companies to produce groups of "companies whose results are

7. See Pain (1980).

8. See Footnote 5 to this chapter for a definition of Minimum List Headings and Orders.

9. It is supervised by the Joint Investment and Index Committee (JIIC) of the Institute and Faculty of Actuaries.

likely to be affected by the same economic, political and trade influences" ¹⁰. The activities of the companies were also taken into account ¹¹. These descriptions found in various places ¹² are rather vague but it would appear that the criteria are predominantly output or end-product based ¹³. No explicit cognisance appears to be taken of the input and technique criteria used in the SIC ¹⁴.

2.3. Impact of Inter-industry Differences upon the Financial Structure of Firms

2.3. 1. Given the admittedly imperfect framework of our analysis we shall now turn to the mechanism of impact of the substantive economic differences among industries upon the financial characteristics of firms. As noted in Paragraph 2.2. 6, these differences may arise from differences in both the industrial and the market environments of firms and in practice it is, therefore, arguable that some of the differences between groups of firms may have their origin in the differences in the market structure and not in the industrial structure of the groups.

2.3. 2. Inter-industry differences arise from different sources and may be broadly categorised as:

- 1) product related
- 2) industry structure related and
- 3) others.

These differences influence the perceptions and the behaviour of firms thereby determining their cost, asset and liability structures.

Related to these differences are the different degrees of business risk to which a firm is subject. The perceived business risk has an important bearing on the investment and financing behaviour of firms and hence upon their financial structure.

10. Plymen (1970), p. 107.

11. Plymen (1970).

12. These include, in addition to Pain and Plymen, op. cit., the special supplements to the Stock Exchange Weekly Intelligence, Haycocks and Plymen (1964) and Short and Brumwell (1973).

13. This was confirmed by Mr. J.C.H. Brumwell of Prudential Insurance Company who is on the JIIC (footnote 9 ante) and writes the annual account of changes in the composition of the FT Actuaries Index in the "Investment Analyst", in personal communication.

14. See Paragraph 2.2. 7.

- 2.3. 3. Impact on Cost of Capital: Business risk unlike financial risk, is associated with the line of business that a firm is engaged in and is largely outside the control of the individual firm. Each industry is regarded as idiosyncratic in terms of the nature of its product, the technology used, the patterns of demand, the patterns of factor prices etc. as well as in terms of the variability of these characteristics. The differences in these characteristics and in their variability over time invest different industries with different degrees of risk. An industry like Textiles which is very vulnerable to consumer tastes and fashions is much more volatile than, say, food. A consumer durable industry like Motor Vehicles is much more sensitive to changes in income levels than Electricity.
- 2.3. 4. Business risk may be defined as the variability of a firm's net cash flows over a given period of time. Net cashflows are a residual of sales revenues after meeting all costs of factor inputs and are subject to variability depending on the characteristics of the industry in which the firm operates. It may, therefore, be expected that the variability of net cash flows will reflect the underlying business risk of the firm. The importance of business risk lies in the fact that since suppliers of capital to the firm (investors and creditors) tend to be risk-averse the acceptance of a project that changes the risk complexion of the firm may cause them to change their required rate of return for investing or extending credit (Van Horne, 1977). Business risk thus alters the expected return on the capital invested and in turn the financing strategies that a firm may possibly pursue.¹⁵.

15. The concept of business risk and its implications for the expected returns and systematic risk of firms have been widely investigated in the literature e.g., Cootner and Holland (1970), Rosenberg and Guy (1976), Martin et al (1979), and Fabozzi and Francis (1979).

- 2.3. 5. Impact on Asset, Cost and Liability Structure: A firm's asset structure consists of fixed assets, current assets and intangible assets such as patents, goodwill etc. and is essentially dictated by the nature and organisation of its production and selling operations. These, together with the cost of factor inputs, would determine the structure of the firm's costs, that is, the relative proportions of fixed and variable costs. Depending on the intensity of fixed costs, the firm will have a high or low operating leverage which in turn determines the volatility of earnings and hence the business risk of the firm. A particular asset and cost structure may be financed in a number of different ways essentially by changing the mix of equity, long term borrowing, short term borrowing and trade creditors. The liability structure is influenced, though not completely determined, by the firm's asset structure. For example, it would be an imprudent financial strategy to finance fixed capital investment by short term bank borrowing. To a degree, therefore, the maturity structures of assets and liabilities tend to be matched (see Chambers, 1967, p. 101).
- 2.3. 6. To the extent that the industry environment of a firm affects the nature and organisation of its operations and the price of its factor inputs, it will also determine the composition of cost, asset and liability structures. It follows that different industry environments will have different influences upon the financial structure of firms. However, a firm's organisation of its operations is not completely externally determined. A firm is not a passive serf of its environment. It has some scope for ingenuity and efficiency in organising its operations. To the extent that such ingenuity is present, firms within the same industry will show variability in their cost, asset and liability structure. Allowing for this variability we may hypothesise that firms in one industry will be differentiated from those in another because of the influence of the industry. We may further hypothesise that financial ratios will reflect the differences in the financial structure of firms arising from that differentiation. The latter hypothesis is, however, subject to the ability of the accounting process to accurately measure and faithfully reflect the economic realities behind the operations of firms as argued at the beginning of this chapter.

2.4. Product-related Causes of Inter-industry Differences in the Financial Structure of Firms

- 2.4. 1. Demand and Variability of Demand: Demand for the product or products of an industry is the *raison d'être* of the firms in that industry. For this reason it constitutes the fundamental determinant of the structure of the industry. Every other aspect of industry is ultimately influenced by, or is intended to influence, demand. As we have seen above the nature and variability of demand is an important aspect of business risk. It also has a pre-dominant influence upon the various components of financial structure.

"Decisions on the distribution of funds between durable assets and current assets are made in the light of present knowledge and present expectations of the course of demand or the supply of the goods produced by the firm and the goods and services used by it".
(Chambers, 1967, p. 92)

- 2.4. 2. Both present and expected demand have a role in shaping the firm's perception of risk and return when contemplating an investment. Variability of demand in the short run for an industry's products depends upon the price elasticity, present levels and distribution of income, tastes and preferences, variability in the prices of presently available substitutes and complements, seasonal factors and a host of economic factors such as interest rates, availability of credit etc. Future demand will be influenced by the changes in tastes and preferences of consumers, in the age or racial composition of population, in the levels and the distribution of income and in the relative prices of the goods and their substitutes and complementary goods and by the availability of new substitutes owing to innovations and inventions. These changes in demand patterns affect different industries differently. Some experience increasing demand for their products and are called growth industries while some others see the demand for their products decline. The growth of consumer durables after the war provides an example of the impact of rising levels of income while changes in spending habits and the impact of cheap foreign imports account for the decline of textiles.

- 2.4. 3 Changes in the general level of income are unlikely to dramatically alter the demand for necessities such as food whereas consumer durables such as cars and refrigerators are likely to be more sensitive to such changes. Thus some industries experience high variability of demand relative to others. Relatively stable patterns of demand will encourage greater investment in fixed assets and by reducing business risk also facilitate raising capital from outside the firm ¹⁶.
- 2.4. 4 Differences in the growth rates of demand between industries lead to differential rates of fixed investment and labour productivity. Fairly continuous expansion of demand and production gives scope for and encourages the installation of new plant in growing industries and thereby fosters modernisation and innovation and exerts pressure to increase productivity in industries with static demand by drawing away labour and making it dearer (Burn, 1958) ¹⁷.
- 2.4. 5 We may thus see that while expected future demand affects the perceptions of risk and the investment and financing behaviour of firms the present demand affects the price and cost margins, labour productivity etc. To the extent that present demand forms the basis of expectations about future demand it also affects the investment behaviour and the asset structure of firms. By influencing the perceived business risk of firms present demand also imposes constraints upon the financing options open to the firm. Demand also indirectly affects the cost and asset structure of firms through their advertising, marketing and innovative activities. These are considered below.
- 2.4. 6 Scale, Technology and Technological Opportunity: The level of technology and the complexities of production in an industry depend upon the nature of the product and the degree and method of processing required to transform the inputs into finished products.

16. Dennison (1959) compared the Cotton and Brewing industries for the period 1949-53 and found that Cotton which suffered big fluctuations in trading profits invested less and relied more on retained earnings to finance investments than Brewing.

17. For example in Salter's (1966) study, electricity, cutlery and rubber industries showed a 200% increase in labour productivity whereas brewing, matches and wallpaper industries showed declining productivity.

The technological sophistication will determine both the minimum scale of operation and the amount of capital expenditure required. The technology of many processing industries such as cement manufacturing, petroleum refining, iron and steel manufacturing requires that production be undertaken on a large scale or not at all. On the other hand in many other industries various stages of production are less integrated (e.g. motor components) and so can be carried out by different firms.

2.4. 7 The minimum economic scale of operation is, therefore, different for the different industries¹⁸. This implies that these industries will differ in their investment in fixed assets like plant and machinery and building. The nature of the production process will also determine the relative proportions of labour and capital to be employed although the products of a given industry may probably be produced by a range of alternative production techniques. Other considerations in the choice of the production method will include the availability of finance and labour and the relative prices of capital and labour. But given these choices it would be reasonable to say that the production technique employed will be a distinct aspect of the industry concerned, imposing a distinct structure upon the composition of assets, liabilities and costs.

2.4. 8 Evidence was provided earlier (see paragraph 2.4. 4), that industries differed in terms of labour productivity and this was attributed to differential rates of technical changes among industries. Industries differ in technological opportunities available to them and innovations and inventions have a tendency to grow, at least in the initial stages, by feeding upon themselves.

"Some industries are far more dependent upon a continuous process of scientific discovery than others. One may point the contrast between the electrical, aircraft, chemical and manmade fibres industries on the one hand and the older textiles, shipbuilding and building on the other". (Allen, 1970, p. 21).

18. For example, see Pratten (1971) who found the minimum efficient scale of production to be different for different U.K. manufacturing industries.

- 2.4. 9 Scherer (1970) studying the rate of innovation in different industries found that the most important cause of observed inter-industry differences in patenting was technological opportunity which he judged to be ultimately dependent on the broad advance of scientific and technical knowledge. Of all the variance in corporate patenting more than 30% was attributed to inter-industry differences in technological opportunity as against 42% to inter-firm differences in sales and 12% to inter-industry differences in the propensity to patent.
- 2.4. 10 Innovation is of two kinds - process innovation and product innovation. The first leads to reduction in the cost of making products presently sold and depending on the elasticity of the demand for those products will lead to growth in demand and expansion of the industry. The second is perhaps even more important than the first in creating new industries and differentiating the old ones. According to Schumpeter (1949, p. 65)

"innovations in the economic system do not as a rule take place in such a way that, first, new wants arise spontaneously in consumers and then the productivity apparatus swings around through their pressure.... It is the producer who, as a rule, initiates economic change and consumers are educated by him, if necessary; they are, as it were, brought to want new things".

Given the differences among industries in technological opportunity it would be expected that some of them would grow much faster than others. This has certain consequences for the financial structure of firms.

- 2.4. 11 It would be expected that science-based industries would invest more than non-science-based industries in research and development ¹⁹.

19. Allen (1970, p. 21.), provides some data on the share of some industries in the total R & D expenditure in the U.K. in the middle 1960's: aircraft (28%), electronics and telecommunications (16%) chemicals and oil refining (14%), textiles (1%) and civil engineering (under 3%).

The result of high R & D activity would be a greater investment in fixed assets in the form of laboratories and in intangible assets like patents. Depending on the accounting policies pursued by firms in different industries, R & D cost will affect the cost and asset structures of these firms.

- 2.4. 12. Where technology is a condition of survival of any industry it increases the business risk of firms in that industry. There is no assurance that the benefits of innovation will be realised in a foreseeable time or at any time. Innovations typically proliferate in industries whose products are far from being necessities. Thus, even if they result in acceptable products they are still subject to the vagaries of demand that we discussed earlier in this section. Where the costs of R & D are built into the cost structure, the operating leverage is raised thus increasing the uncertainty about return to the investors. The higher degree of business risk associated with innovative industries will, therefore, influence the availability of external finance and the cost of that finance. The pattern of financing that results from this constraint will be reflected in the financial structure of the firm.

2.5. Structural Causes of Inter-industry Differences

- 2.5. 1. The differences which we have discussed so far arise mainly from the demand and technical characteristics of the products. Although in conventional economic theory these characteristics are assumed given and, therefore, outside the control of firms we have seen that the assumption is not valid except in the shortest run and that modern industry does not passively adapt to externally determined technical and market conditions. Even as the present technological opportunity of industry heralds tomorrow's products and shapes tomorrow's markets, the present industry (and market) structure has a similar transforming potential and influences the size, the cost and asset structures and the performance of different industries.

- 2.5. 2. Industry is multidimensional in its structure. These dimensions have been conventionally identified as seller concentration, buyer concentration, product differentiation and entry barriers (Devine et al, 1979). Within the Structure-Behaviour-Performance paradigm (George, 1974) it is hypothesised that the various dimensions of the industry structure influence the behaviour of firms in that industry resulting in their performance. Different market or industry structures within this paradigm will, therefore, evoke different behavioural responses from the firms concerned leading to differential performance of industries. The framework has been criticised on the grounds that the underlying assumption that the market is an exogenously given environment is no longer valid and that firms have the power, through innovation, product differentiation etc., to alter the market structure. Moreover, firms in oligopolistic markets at least do not act under the profit maximising constraint.
- 2.5. 3. Despite its weaknesses the Structure-Behaviour-Performance model can be used to study how the financial structures of different industries are influenced by the various dimensions of the industry structure. Market structure has a significant impact on
- a) the operating characteristics like plant size and the attendant costs
 - b) innovative activity
 - c) pricing and advertising and
 - d) productivity and overall performance.
- 2.5. 4. The positive association between concentration and profitability has been established in some earlier studies ²⁰. There is also some evidence that innovational activity is related to concentration although this is much more conclusive over intermediate ranges of market concentration (Devine et al, 1979, p. 216). Another influence on innovative activity is the differentiability of the products of an industry. Some industries like consumer non-durables are more differentiable than industries like consumer durables and investment goods. Comanor (1967) has suggested that research outlays should be higher in industries where products are

20. See George (1974) Chapter 6.

differentiable. It would, therefore, be expected that firms in such industries would carry a higher proportion of their total assets in the form of intangible assets such as R & D expenditure than those in other industries.

2.5. 5. Product differentiation and advertising are means by which firms in oligopolistic markets seek to increase their market share as an alternative to price competition. They are also used by those firms to restrict the entry of new firms. Advertising expenditure varies widely from industry to industry²¹. The level of advertising tends to be high in highly concentrated oligopolistic markets since sales promotion expenditure is regarded as a safer form of rivalry than price competition, often to the point where the exceptionally high competitive advertising campaigns tend to cancel one another out. (George, 1974, p. 126-127).

2.5. 6. The above discussion indicates that the strategies pursued by firms in response to their market environment involve investment and expenditure which affect their financial structure. Thus differences in the financial profiles of firms are partly attributable to the structural characteristics of their respective industries. There are, however, other differences which arise from historical factors such as trade custom.

2.6. Other Sources of Inter-industry Differences

2.6. 1. Certain aspects of the financial structure of firms are to a large degree determined by trade custom and historical practice. For example, Henderson (1959) divides the factors determining trade credit policies into "industrial" and "financial". These are "industrial" if in some industries

"it was a clearly established custom that trade credit should be given to customers for a certain period. An expansion of output would then lead automatically to an expansion of trade credit granted" (p. 93).

21. In 1963, advertising expenditure "as a percentage of net output varied from over 30% for soap, detergents and toilet preparations to being negligible for shipbuilding and marine engineering and for many other industries within the Orders". (George, 1974 p.80)

Thus the relative importance of trade credit in the asset and liability structures of firms will depend on the trade custom of the industry to which they belong. For example, trade credit is likely to be shorter in the retail sector and in the industries selling low-valued or short lived goods such as food than in the manufacturing sector or industries such as consumer durables.

- 2.6. 2. The oil industry has a long record of financing its expansion through internally generated funds. This means that this industry will have a smaller dividend payout than other industries. The tendency to rely on internal sources in the oil industry may be due to the high volume of funds, the high degree of international diversification, the greater uncertainty associated with the returns and the consequent problems of raising inexpensive capital from the capital markets. Another major reason is that historically oil developed as a family business (Channon, 1973).

2.7. Factors Eliminating Inter-industry Differences

- 2.7. 1. The following factors will tend to minimise if not eliminate inter-industry differences:
- 1) the competitive process tending to equalise profit rates in different industries by encouraging firms in low profitability industries into high profitability ones by diversification or changeover
 - 2) increasing product and geographical diversification of firms undertaken for reasons of greater profitability, stability, growth, risk reduction or avoidance of anti-monopoly restrictions and
 - 3) the definitional and data limitations of practical industrial classification systems obscuring inter-industry differences (see Section 2.2).

These factors will each tend to eliminate inter-industry differences in varying degrees. It is, however, difficult to disentangle the effect of any one factor from that of the others. In our analysis of results presented in Chapters 7 to 9 we examine some of these factors as possible sources of similarity of firms across industries.

2.8. Conclusion

- 2.8. 1 The picture that emerges from our discussion of the sources of inter-industry differences is that they are both diverse and complex. We have described the mechanism by which these differences in basic economic attributes affect the investment and financing decisions and, hence, the financial structure of firms. We may now specify that firms which belong to the same industry and are, therefore, homogeneous with respect to their substantive attributes will be homogeneous with respect to their accounting numbers. Given this specification, the ability of accounting numbers of firms in different industries to reflect the differences in substantive economic attributes will, as stated in Section 2.0, depend upon the fidelity of the accounting process to reproduce those differences.
- 2.8. 2 The imperfections of accounting systems and the discretionary variations in accounting policies from firm to firm may impair the descriptive ability of the resulting accounting numbers and thereby diminish the utility of those numbers to those who base their decisions on them. Thus descriptive ability is an essential pre-condition for the usefulness of accounting numbers and can, therefore, be used as a criterion for evaluating the informational content of accounting numbers. In the next chapter we compare this to the other criteria proposed in the literature for this purpose and discuss the related issues which are of considerable importance to the development of accounting theory. We also propose an operational measure of descriptive ability for the purpose of our study with a view to analysing the results presented in Chapters 7 to 9 and assessing the usefulness of accounting numbers.

Chapter 3

Evaluating the Usefulness of Accounting Numbers: A Conceptual Framework

3.0. Introduction

Our search for accounting numbers which distinguish between firms in different industries in an economically meaningful way is premised upon the assumption that the accounting system presently in use is capable of recording the underlying substantive economic attributes of firms. The ability of the accounting system to perform this function has, however, been a subject of considerable controversy in recent years. This has cast doubts upon the general utility of accounting numbers to the users of accounts which implies that the informational content of these accounting numbers is not adequate. The question of adequacy raises the question of the purpose of accounting systems. Accounting is an information system and the assessment of the informational content of a particular information system such as accounting necessarily implies the existence of criteria which ought to be derived from the theory that underlies that system and must be related to the purpose of the system.

There have been several approaches to the theory of accounting and these have inspired authors to propose different criteria for the evaluation of accounting numbers. Some of these criteria are in conflict with the nature and function of accounting and also suffer from conceptual and operational problems. In this chapter these criteria and the associated problems are discussed and "descriptive ability" is proposed as an alternative criterion.

3.1. Broad Approaches to the Theory of Accounting

- 3.1. 1. The Committee on Concepts and Standards for External Financial Reports of the American Accounting Association (AAA) in its Statement on Accounting Theory and Theory Acceptance (1977, hereafter SOATATA) identified three broad approaches to the theory of accounting:

- 1) the classical approach which emphasises normative, a priori considerations in the construction of accounting theory
- 2) the decision-usefulness approach which emphasises the primacy of the user of accounting statements and the satisfaction of his information needs as the main objective of accounting and
- 3) the information economics approach which treats information as an economic commodity whose costs and benefits are among the decision variables in the choice of a particular type of accounting information. "At present, however, the approach is still too general to provide definitive answers to existing policy issues" (SOATATA, p. 25).

3.1. 2. The inductive, rationalising approach of authors like Ijiri (1975) is regarded as a variant of the classical approach. The classical approach may be exemplified by such statements as the following:

"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 these resources. Its principles should be aimed at the achievement of these functions" (Sprouse and Moonitz, 1962).

Thus accounting according to the classical approach is a measurement process founded upon normative principles which include objectivity, verifiability, timeliness etc.¹, and operating independently of the user.

"The principles are not inferred from the personal preferences of the users of accounting data. As a consequence the relationship between the normative standards and the individual preferences of decision makers is indirect" (SOATATA, p.33).

The normative approach to the determination of appropriate accounting methods and the content of financial statements has led to a growing dissatisfaction among the users of those statements. According to the Corporate Report (ASSC 1975, p. 47)

1. See SOATATA (1977) Chapters 1 and 2 for a summary of these criteria.

"current reporting practices do not fully meet all the needs of the user groups" and it identifies certain drawbacks concerning the scope and content of published financial statements.

- 3.1. 3. Decision-Usefulness Approach: The dissatisfaction with normative standards in recent years has resulted in a strong orientation towards decision-usefulness.

The American Accounting Association in "A Statement of Basic Accounting Theory" (1966) defined accounting as "the process of identifying, measuring and communicating economic information to permit informed judgments and decisions by users of information".(p. 1) This decision-usefulness approach elevating the user to the status of the primary focus of accounting finds a resonant echo in the U.K. The fundamental objective of corporate reports, according to the Corporate Report, 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". (p28).

The definition makes no explicit reference to the decision context but the term "useful" necessarily implies that context. Since descriptive ability which we shall propose as a criterion falls within the broad scope of the decision-usefulness approach we shall consider it in some detail.

- 3.1. 4. Variants of the Decision-Usefulness Approach: SOATATA identifies two strands of the decision-usefulness approach in the literature distinguished by the differing emphasis on the decision model and the decision maker. This distinction is based on the view that a decision model could be constructed independently of the decision maker and that the relevance of any information could be assessed by using the decision model alone ². This implies the existence

2. See for example Sterling (1972) - "Decision models are abstractions which are separate and apart from decision makers. For example, the EOQ (i.e. Economic Order Quantity) model is an idea which can be thought about separately from the persons who hold or use that idea" (p. 201).

of some optimality criteria which the model would seek to achieve. On the other hand where the focus is on the decision maker it is his use of the information which would determine its usefulness or relevance irrespective of whether his use of the information is optimal or not ³. The distinction between these two approaches to decision relevance is important because of the different criteria for evaluation of accounting information to which they have given rise.

- 3.1. 5. Relevance, Decision-Usefulness and Prediction: Relevance is an essential condition for the decision-usefulness of accounting information ⁴. Decisions are concerned with and motivated by the need to select among alternative courses of action in the future in order to achieve pre-determined objectives. To select among the alternative courses of action the decision maker has to predict or, in other words, generate the scenarios that will result from his actions and such predictions are made in the face of uncertainty about the future by making use of the available information. Decision-usefulness of information, therefore, connotes a concern primarily with information regarding future events. Therefore, a necessary test of the relevance of reportable data is their ability to predict events of interest to users.
- 3.1. 6. Predictive Ability as a criterion of Relevance: Beaver et al (1968) proposed predictive ability as a criterion for evaluating alternative accounting measurements.

3. See Abdel-Khalik (1971).

4. Relevance is said to be a necessary but not sufficient condition (SOATATA, p. 16). The other additional attributes suggested are reliability, comparability etc. which are again highly normative (p. 13). This view does not, however, affect our arguments.

"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" method for that particular purpose" (p. 675).

Implied in this approach is the belief that accounting numbers possess an inherent ability to make optimal predictions. Beaver et al do not, however, provide any rationale for their belief.

- 3.1. 7. Such belief is, however, inconsistent with the nature of accounting and arises from a misconception of the predictive process. Accounting is a measurement process and measures what has happened and not what is going to happen.

"Measurement is a process of discovering an extant condition and prediction is concerned with a future condition. Thus, prediction requires some kind of law connecting the past and the present with the future" (Sterling, 1967 p. 108).

Such a law is not implied by the measurement process per se and is outside its scope.

- 3.1. 8. Nature of the Predictive Process: The predictive process is made up of four constituent parts:
- 1) the event predicted
 - 2) the information cues
 - 3) the functional form of the predictive model or the combinatory rule for combining the information cues and
 - 4) the weights attached to each cue
- Parts 3 and 4 together form the predictive model. Accounting numbers which serve as information cues or data inputs are thus just one part of the predictive process and their predictive power is a function of the other three parts.

- 3.1. 9. There is as yet no consensus on which events are to be predicted by accounting numbers. The report of the Committee on Corporate Financial Reporting of the AAA (1972) raises the question "what types

of events ought to be predicted?" and suggests that both a priori and empirical studies are needed to answer it. Again predictive ability of an accounting number may be event-specific and, therefore, devoid of universal validity. Beaver et al themselves acknowledge these problems saying that "even if a measure is a better predictor of one event (e.g. loan default), it is not necessarily a better predictor of other events". (p. 682).

- 3.1.10. It has been argued that it is inappropriate to speak of prediction except in association with the person who makes the prediction. Greenball (1971, p. 3) says that "a number, of its own accord, cannot predict anything. Only a person or a prediction model developed by a person can make a prediction". Ashton (1974) expresses a similar view that

"existing predictive ability research generally does not explicitly recognise that predictions (or at least prediction models) derive from people and that different people may employ for the same prediction task, prediction models which require different data and/or use data in different ways" (p. 720).

- 3.1.11. This argument implies that the specification of the various components of a prediction model depends entirely upon the choice/s made by the person making the prediction. Thus cues to be included in the model, the combinatory rule employed and the weight to be attached to each cue are a matter of judgment of the predicting person and accounting numbers by themselves cannot provide any prediction. It can be seen that this approach emphasises the importance of the decision maker while in Beaver et al's view he is largely dispensable. We may call the prediction made by the user-specified model "user prediction" and the prediction made without the intermediation of the user "direct" or "universal prediction". The relationship between user prediction and direct prediction may be placed in proper perspective with the help of the lens model framework developed by Brunswick (see Hammond, Hursch, and Todd, 1964 for a description of the model).

3.2. Brunswick Model for Evaluation of Information Processing Performance

- 3.2. 1. In the Brunswick lens model framework man is viewed as an information processor who has to make inferences about an uncertain future from information which is essentially probabilistic in nature and the model is used as a means of studying and evaluating his performance as a probabilistic information processor. This "probabilistic functionalism" approach is well suited to the study of inferences based on accounting numbers which, being products of a system characterised by a large degree of subjective estimation and wide diversity of accounting practices, can be regarded as random variables (Whittington, 1979 and Gonedes & Dopuch, 1979). Not surprisingly, therefore, the Committee on Accounting Valuation Bases of the AAA suggested that the lens model framework be used for evaluating alternative accounting numbers (quoted in Ashton, 1974).
- 3.2. 2. In the process of forming his judgment about a predicted event (also referred to as a distal or ecological variable) a person makes use of a set of cues which are of a probabilistic nature. The cues may possess varying degrees of validity as predictors of the event. However, given cues of a certain validity the accuracy of the decision maker's judgment will depend upon how he utilises the cues. Ideally, the cues should be utilised in accordance with their "inherent" validity. That is, there must be a congruence of real validity and perceived validity of the cues. Brunswick used the analogy of a convex lens to represent these two aspects of the judgment formation process and the inter-relationship between ecology and its perception based on available probabilistic cues (see Fig. 3.1.).

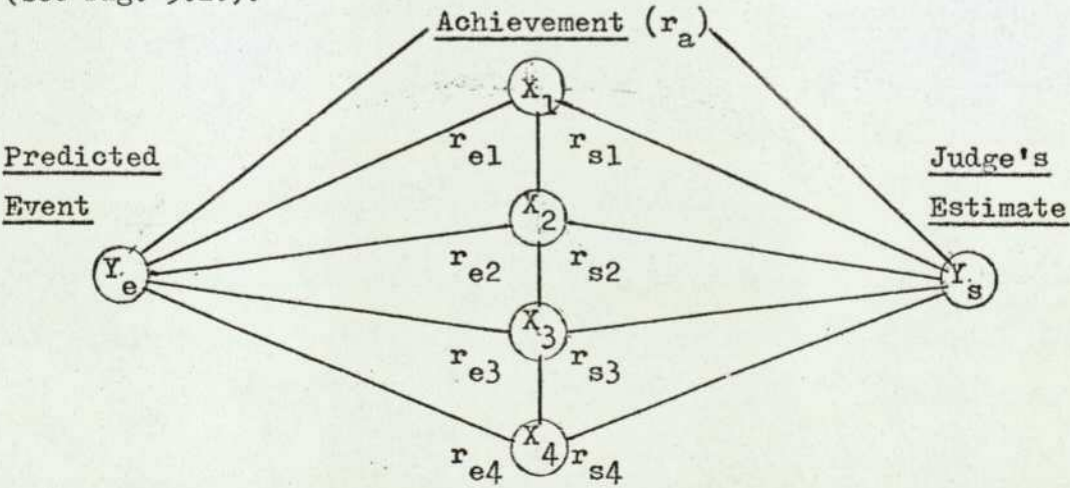


Figure 3.1 Brunswick Lens Model

- 3.2. 3. In the figure Y_e is the ecological event which the judge seeks to predict and Y_s is his prediction or response. The X_i 's are the probabilistic cues. To represent the relationship between the distal variable and the cues on the one hand and that between the cues and the judge's prediction on the other multiple regression models have been used in the literature relying upon the assumption of linearity. The correlation coefficients r_{ei} between the distal variable and the cues are a measure of the ecological validity of the latter while the cue utilisation or perceived validity is indicated by the correlation coefficients r_{si} between the cues and the judge's prediction. The accuracy of the judge's prediction is measured by the correlation coefficient r_a between the prediction and the distal variable.
- 3.2. 4. Main Features of the Lens Model: The model assumes a linear relationship between the cues and the predicted event as well as between the cues and the judge's prediction. Linearity may not be a valid assumption in all cases and its appropriateness has to be confirmed empirically. Secondly, the judge's prediction accuracy is determined by the statistical characteristics of the environmental and organismic (that is to say the judge's inferential) system (Hursch, Hammond and Hursch, 1964). In order to evaluate a judge's achievement we should know the statistical properties of the prediction situation, e.g. the inter-correlations between the cues and the correlations between the distal variable and the cues. Considering the case where the number of cues is increased from three to four, Hursch et al argue that

it would be impossible to say whether the higher achievement in the four cue situation was due to the increased number of cues or to a relaxation in statistical restrictions on achievement brought about by the change in relations among the stimulus variables" (p.44).

- 3.2. 5. A pre-condition to the use of the lens model for the purpose of assessing inferential capabilities and judgmental accuracy is that we know

what ecological validities are between cues and variable(s) to be estimated, what the reliabilities of the cues are, how much determinacy there is in the cue criterion variable system as a whole, or how much and which part of the system is dependably linear and how much and which part is non-linear" (Hammond, Hursch and Todd, 1964, p. 453).

- 3.2. 6. Lens Model in the Accounting Context: It will be seen that the two sides of the lens model bear a close resemblance to the two strands of the decision-usefulness approach we discussed earlier. Beaver et al's predictive ability criterion is related to the ecology side of the lens. The response side of the lens has been proposed as a means of assessing use of accounting information by the users of financial statements (Report of the Committee of the AAA on Accounting Valuation Bases quoted in Ashton, 1974 hereafter "the Committee"). The reason that the Committee chooses to ignore the ecology side of the lens is that the distal variable is often not available. They, therefore, suggest that the use of accounting data by decision makers can be examined specifically on the basis of:
- 1) which pieces of data are used and
 - 2) how they are combined by the decision maker in the process of making a prediction. If the distal variable is not available

"one may evaluate such bases via experiments that provide judges with data secured via alternative bases and involve examination of the judge's cue weighting scheme. In effect this type of approach attempts to provide evaluations based upon the judge's choices" (quoted in Ashton, 1974, p.726).

- 3.2. 7. Validity of the Lens Model Framework in the Accounting Context: The partial use of the lens model proposed by the Committee and the reasoning behind it are curious. Elaborating on the Committee's view that the distal variables are not easily available Ashton argues that

"specification of criterion (i.e. distal variable) values in accounting contexts involves many problems. Such criterion values are typically either

- 1) separated from the cues by a period of time
- 2) imprecise because of measurement difficulties or
- 3) affected by events which are uncontrollable by and possibly unknown to the decision maker" (1974, p. 725).

The reasoning of both the Committee and Ashton is fallacious and unsustainable. Firstly, the lens model is concerned with ex-post evaluation of inferential accuracy when the criterion value is known. The validity coefficients and cue utilisation coefficients can only be determined ex-post and not ex-ante. Even the partial use of the model to evaluate the perceived validities of the alternative accounting numbers as suggested by the Committee can only be done ex-post and at that time the criterion value will have become available.

- 3.2. 8. Secondly, the lens model is not and was never intended as a mechanism for assessing the informational validity of the cues but to ascertain judgmental accuracy based on given cues of given informational validity. As Ashton points out,

"using a descriptive model to determine the data to be supplied to a decision maker is a departure from the typical use of the lens model framework" (1974, p. 727).

The model has been put to conventional use in the accounting context by Libby (1975) and Wright (1977).

3.3. User Prediction Model and Assessment of Perceived Validity

- 3.3. 1. Perceived validity may be determined by the use and relative importance of information cues to the user. Determination of perceived validity, therefore, requires identification of the user's prediction model. It is for the purpose of such identification that the Committee recommended the partial use of the lens model although as we have seen this does not require the lens model framework. What is necessary, is to capture the user's prediction model and then examine the functional form and the cue weighting scheme incorporated in the model so as to assess the relative importance of the different information cues in the data set.
- 3.3. 2. Using perceived validity as a basis for evaluating accounting numbers gives rise to conceptual as well as methodological problems. On the conceptual side, there is no agreement on the user whose perceived validity should be the basis of evaluation. Perceptions of validity are likely to differ not only across functional groups

such as investors, creditors, employees etc. but also from one user to another within the same functional group. Thus universal agreement on the importance and usefulness of an accounting number is almost impossible.

- 3.3. 3. Secondly, if between two alternative accounting numbers one has a stronger structural relationship to the criterion variable than the other but this relationship is misperceived, the perceived validity criterion will lead to the rejection of the right number and acceptance of the wrong alternative. In the absence of an independent measure of the ecological validity of the accounting number there is no way of identifying the misperceptions of the users. The availability of such an independent measure, of course, makes the assessment of perceived validity a rather superfluous exercise.
- 3.3. 4. Thirdly, implied in the perceived validity approach is the assumption that decision makers are rational. It would not be remiss to examine how far this assumption is sustainable in practice. There is an impressive corpus of literature in experimental psychology which deals with the attempts to study the judgmental processes of human beings (see Goldberg, 1970 for a discussion and Slovic, 1972 for references to this literature). Slovic, Fishchoff and Lichtenstein (1976) conclude that

"experimental results indicate that people systematically violate the principles of rational decision making when judging probabilities, making predictions or otherwise attempting to cope with probabilistic tasks".

- 3.3. 5. Slovic et al attribute this subrational behaviour to what Simon (1979) describes as "Bounded Rationality". The theory of Bounded Rationality asserts that cognitive limitations force decision makers to construct simplified models of the world in order to deal with it (Slovic et al, 1976). Simon argues that the decision maker

"behaves rationally with respect to this simplified model and such behaviour is not even optimal with respect to the real world. To predict his behaviour we must understand the way in which this simplified model is constructed and its construction will certainly be related to his psychological properties as a perceiving, thinking and learning animal" (Simon, 1957, p. 198).

"Rationality is bounded when it falls short of omniscience. And failures of omniscience are largely failures of knowing all the alternatives, uncertainty about relevant exogenous events and inability to calculate consequences" (Simon, 1979, p. 502).

3.3. 6. Kahneman and Tversky (Slovic et al, 1976) provide evidence that humans often violate normative principles of prediction. One such principle is that the variance of one's predictions should be sensitive to the validity of the information on which the predictions are based. If the validity is not perfect predictions should be regressed towards some central value. Furthermore, the lower the validity the greater the regression should be. Kahneman and Tversky have observed that otherwise intelligent people ignore these principles even when they are using information that they themselves consider of low validity. They also found that people had greater confidence in predictions based upon highly redundant or correlated predictor variables (Slovic et al, 1976).

3.3. 7. Both these findings have serious and unfavourable implications for the perceived validity criterion ⁵. Even if the validity of a given accounting number is correctly perceived it may not be correctly reflected in the prediction model. Therefore, the validity of an accounting number derived from modelling the prediction of the user may not be a correct measure of the perceived validity of that number. This discrepancy between the explicit and implicit perceptions of judges has been well demonstrated in experimental psychological literature. Slovic and Lichtenstein (1971), for example, have

5. A caveat is probably appropriate here. The studies quoted above have been carried out in situations which did not involve the processing of accounting information. Nevertheless it is believed that their conclusions are not wholly inapplicable to the accounting context.

Found that judges strongly overestimate the importance they place on minor cues and they underestimate their reliance on a few major variables. From a much more recent study (1977) to capture judgment policies, Zedeck and Kafry conclude that

"the important elements as identified by the policy capturing procedure were viewed as less important by the subjective procedure; the opposite holds for the unimportant or minor elements of the policy capturing results which received higher assessments by the subjective procedure" (p. 281).

3.3. 8 Assessment by Self-explication: An alternative method of assessing the perceived importance of accounting numbers is by self-explication using questionnaires. This approach has been followed in the literature, for example, by Baker and Haslam (1973) and Buzby (1974) in the U.S.A. and by Firth (1978) in the U.K. The measurement of perceived validity by this method depends upon the degree of self-insight that the judges possess into their own judgmental processes. The explicit weighting of information cues by the judges ascertained by this method may be compared to the implicit weighting derived from modelling the judge. We have seen the conclusions of Zedeck and Kafry based upon such a comparison in a non-accounting context. Wright (1977) has attempted a similar exercise in an accounting context and his results suggest a general tendency for individuals in accounting settings to display statistically significant self-insight into relative weighting of information cues. However, a caveat to be attached to his and the other studies we have cited is that many of these have been derived from laboratory style experiments using students. Such artificiality of task structure and environment may well detract from the generalisability of the results (Abdel Khalik, 1974).

3.3. 9 If the above discussion has shown up man's competence in processing probabilistic information as a cosy, self-laudatory myth there is even more evidence of the frailty of his judgments. He suffers from several kinds of bias in forming his judgments. Tversky and Kahneman have observed that the use of what they call the "availability heuristic" gives rise to judgmental bias (Slovic et al, 1976). This heuristic involves judging the probability or

frequency of an event by the ease with which relevant instances are imagined or by the number of such instances that are readily retrieved from memory ⁶.

- 3.3.10. Tversky and Kahneman demonstrate another kind of bias called "anchoring bias" arising from following the heuristic device known as "anchoring and adjustment". In this process a natural starting point or anchor is used as a first approximation to the judgment. The anchor is then adjusted to accommodate the implications of additional information. Typically, the adjustment is crude and imprecise and fails to do justice to the importance of additional information (Slovic et al, 1976). Tversky and Kahneman (1974) have found that the degree of adjustment depends upon the anchor level. That is, the judges could not evaluate the additional information correctly.

"Men perceive a datum accurately and are well aware of its individual diagnostic meaning but are unable to combine its meaning properly with their prior opinions and with the diagnostic meaning of other data when revising their estimates" (Slovic, 1972 p. 788).

In the most recent experiment designed to study the use of the anchoring and adjustment heuristic by auditors in audit decision tasks Biddle and Joyce (1978) have observed systematic audit judgment errors resulting from its use.

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6. For example, a bank lending officer who has had little experience of borrower default or bankruptcy may seriously underestimate the likelihood that a given loan application may cause problems subsequently. Conversely a recent bad experience may well make him overcautious.

3.3.11. We may summarise our criticism of the perceived validity approach to the evaluation of accounting numbers as follows:

- 1) there is no agreement on the type of user whose perceived validity is to be assessed
- 2) judges may seldom agree on the importance that they attach to the same information items
- 3) this approach requires the assumption of rationality among users of accounting information. Available evidence suggests that human beings are not only irrational but also biased in their judgment
- 4) on the methodological side there is divergence between implicit and explicit weights which judges attach to various cues. Therefore, the two methods do not yield the same results
- 5) it is essential to have an external criterion in order to judge the validity of judges' predictions. Otherwise it is not possible to assess the significance of the perceived validities of accounting information.

3.4. Materiality as a Criterion

3.4. 1. Materiality of accounting numbers has been proposed as an alternative criterion of evaluation.

"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 is disclosed or if net income or some other significant statement item were increased or decreased by the amount under consideration?" (Hicks, 1964, p. 170).

Thus, materiality has been defined in terms of relevance to decision making. Moreover, it is not objective materiality but perceived materiality that is implied in the above definition. Thus, this criterion is not dissimilar to the perceived validity criterion discussed earlier and as such suffers from the same flaws as the latter does. These flaws are further reinforced by the problems of defining "an average, prudent investor or a reasonable person".

3.5. Descriptive Ability as a Criterion

- 3.5. 1. The foregoing examination of the different criteria of relevance proposed in the literature for evaluating the informational content of accounting numbers shows that none of the extant approaches is conceptually sustainable and operationally credible. What is required is a criterion that is not only objective but also in accordance with the quintessential nature of accounting which, as argued earlier, is a measurement process which measures phenomena which are determined by the decisions of firms in response to forces generated by the environment in which they operate. "The relevance of accounting numbers... lies in the degree to which they validly measure the effect of decisions which the management in present and past periods has made" (Greenball, 1971, p. 2).
- 3.5. 2. If the system of measurement which, in our case, is a given set of accounting rules, is strictly valid the end-product of that system must be wholly free of "distortion". In other words, a valid accounting method must produce numbers which will reflect the true impact of decisions made by firms in response to the static and dynamic aspects of their environment. To the user of accounting information, accounting numbers should provide a key to the understanding of the cumulative decision processes of a firm and thereby enable him to evaluate the environmental stimulus - decisional response system of that firm. A test of the usefulness of accounting numbers to him would, therefore, be the extent to which accounting numbers describe the characteristics of the firms' operating environment. This may be viewed as a test of the "descriptive ability" of accounting numbers. Descriptive ability as a test of the usefulness of accounting numbers is not dependent upon the perceptions of the users of those numbers. It is, therefore, wholly objective. It is not concerned with the future condition of firms but with their present condition as shaped by the events of the past and expectations of the future. It is, therefore, guided by the same temporal retrospectiveness as the accounting process itself in contrast to the predictive ability criterion. Thus, it avoids the problems inherent in the extant criteria discussed above.

3.5. 3. Conceptual Analysis of Descriptive Ability: The descriptive ability criterion is, however, not completely free from defects. These defects may often impair the ability of accounting numbers to reflect faithfully the economic attributes of firms. In a stimulating paper (1979), Gonedes and Dopuch point out the pitfalls in the use of accounting numbers to make inferences about the substantive economic attributes of firms' operations. They argue that, accounting numbers being random variables

"the stochastic properties of a given firm's accounting numbers - for example, the numbers' expected values, variances and autocorrelation functions - depend, in general, upon the economic environment, the firm's production-investment and financing decisions and the firm's accounting techniques. Since the economic environment is a determinant of the attributes of firms' decisions we can simply say that the stochastic properties of a firm's accounting numbers are jointly determined by its accounting techniques and the attributes of its decisions". (pp 386-7)

3.5. 4. This joint determination would invalidate the assumption underlying many economic studies that the observed systematic properties of accounting numbers such as their mean and dispersion reflect the substantive economic attributes of firms' operations.

"Some changes in the properties of individual firm's accounting numbers may have been induced by changes in these accounting techniques and not by changes in the relevant attributes of their decisions" (Gonedes and Dopuch, p. 388).

Similarly, in a cross-sectional analysis, observed differences in the accounting numbers of different firms may be due to either the differences in the economic attributes of the decisions of those firms or the differences in the accounting techniques used by them. In the latter event any inference of congruence of the economic attributes of the firms concerned is clearly untenable.

3.5. 5. The accounting techniques used to produce the observed accounting numbers are thus actively non-neutral and capable of mischief. This non-neutrality of accounting techniques has, of course, been long recognised by academics and accounting practitioners alike.

Their solution to the problem is to restate reported accounting numbers of different entities using a single accounting basis. Such a restatement is assumed to hold the effects of accounting techniques constant thus permitting the attribution of observed differences in accounting numbers to the underlying substantive economic attributes. The preference for one accounting technique over another is often motivated by the quest for the "true" or "ideal" numbers ⁷, a quest for certainty in our uncertain world.

3.5. 6. Gonedes and Dopuch argue that this restatement approach is inappropriate because

- 1) the restatement techniques are as arbitrary as the conventional techniques and
- 2) firms' decisions are not invariant to the techniques. The "true income" models

"have no special virtue for a world of uncertainty, especially one with potentially heterogeneous agents, imperfect markets and multiperiod horizons... They do not provide values of accounting numbers more or less informative than values based upon conventional accounting techniques". (pp. 391-2).

3.5. 7. Firms' decisions are materially affected by the information they are required to communicate. This kind of interaction between the information sender and information sent by him has been termed "information inductance" (Prakash and Rappaport, 1977).

"Individuals, in general, are aware of the fact any information they communicate to the environment might be used by the recipients (both intended and unintended) in choosing their own plans and actions, or in choosing their evaluative and control actions towards the information sender. Information senders, therefore, tend to anticipate the possible use to which the information might be put and the consequences of such use" (p. 30).

7. For example, the different valuation models such as replacement value, exit value, discounted cashflow etc. are all based on different definitions of income, each of which is defended by its proponents as measuring true income. See Lee (1974).

3.5. 8. Prakash and Rappaport argue that

"an individual's anticipating the consequences of his communication might lead him - before any information is communicated and, hence even before any consequences arise - to choose to alter the information, or his behaviour or even his objectives" (p. 30).

For example, where management compensation is related to the firm's performance as measured by accounting numbers the decisions of the firm's management will depend upon the accounting technique used (Gonedes and Dopuch 1979, p. 389).⁸ Information inductance in the context of external reporting has far-reaching implications.

"Management's anticipations of the feedback effects of the firm's external reports will reflect in changes in management's resource allocation decisions within the firm and hence, collectively in the industry and the economy".
(Prakash & Rappaport, 1977, p. 36-37)

3.5. 9. It follows from the foregoing discussion that

"accounting techniques are, in general, among the determinants of accounting numbers' systematic properties both because the techniques constitute accounting numbers' computational specification and because there may be connections between the techniques and managements' operating and financing decisions" (Gonedes and Dopuch, 1979, p. 390).

How serious is the distortion in the observed accounting numbers that is potentially caused by the accounting technique? If it is serious enough to mask the true, or introduce spurious, relationships between the systematic properties of the accounting numbers and the substantive economic attributes of firms it is clear that the observed accounting numbers will not satisfy the descriptive ability criterion. However, what evidence there is in the literature appears to suggest that such concerns may be exaggerated.

8. This is an instance of "evaluation apprehension" influencing the choice of accounting technique.

- 3.5.10. In a recent study Nair (1979) has investigated the impact of accounting methods on tests of economic hypotheses by assessing the effect of alternative depreciation and inventory techniques on differences in rankings of competing investment hypotheses. He fitted four investment models derived from economic theory to six sets of data for a sample of ten U.S. firms. Each set was computed by one of six accounting methods which were pairwise combinations of three depreciation methods and two inventory valuation methods. (He ignored the interaction between accounting and investment policies). The investment models were ranked for each accounting method and rankings were compared.
- 3.5.11. The rankings of the four models were not identical across accounting methods. There is thus some evidence that accounting methods do have potential for distorting the rankings of investment models. However, the best and the worst models were more or less identical across the different accounting methods. Nair concluded that the distortionary impact of accounting methods should not be exaggerated. This conclusion that the impact of basic economic attributes upon accounting numbers may be relatively greater and is unlikely to be swamped by the distortionary effect of accounting techniques is indeed reassuring.
- 3.5.12. Descriptive Ability in the Context of the Present Study: In order to study the effects of alternative accounting techniques upon the systematic properties of accounting numbers it is necessary to hold the substantive economic attributes constant. Gonedes and Dopuch (1979, pp.400-1) suggest the use of industry groups for this purpose since they may be
- "presumed to be homogeneous with respect to the substantive attributes of their decisions... From the perspective of economic theory, grouping firms according to industry membership corresponds to grouping them in terms of decisions that will tend to have highly similar attributes".
- They further suggest that for a given set of (accounting) techniques, analyses can be conducted across groups to determine whether the given technique "masks" the different attributes of decisions.

3.5.13. In our research our aim is to demonstrate the descriptive ability of accounting numbers i.e. their ability to describe the substantive economic attributes of the operations and decisions of firms. Descriptive ability is, of course, a criterion that applies to the whole range of substantive economic attributes of firms' decisions and may be tested in relation to any of these attributes. Nair's study represents an attempt to test it in relation to capital investment decisions. Our study aims to demonstrate it with respect to the industry-related differences in the substantive economic attributes of firms. This demonstration is with regard to the totality of accounting techniques used by the firms in our sample and not to the relative descriptive powers of different techniques. We, however, need to examine the impact of different accounting techniques being employed by firms both within and across industry groups.

3.5.14. We may consider two alternative possibilities:

- 1) accounting methods are uniform within an industry and
- 2) they are random within and across industries.

If we accept the first proposition, industries are homogeneous with respect not only to their substantive attributes but also their accounting techniques. In this case the observed differences in accounting numbers will, at least, in part be attributable to the differences in accounting techniques. However, if the differential impact of accounting techniques is relatively small we may still validly infer substantive economic differences from the observed differences in accounting numbers. If the second proposition is true the effect of accounting technique on the observed differences may be taken as random and any inference of substantive economic differences based on the observed differences of accounting numbers will be quite valid. There is, however, very little evidence in the U.K. which would help us decide which the more appropriate proposition is.

3.5.15. Among the significant matters for which different accounting methods are recognised which may have a material effect on the observed accounting numbers are

- 1) depreciation of fixed assets
- 2) treatment of intangibles such as goodwill, R & D patents etc.
- 3) valuation of stocks and work in progress
- 4) treatment of long term contracts
- 5) treatment of deferred taxation and
- 6) treatment of hire purchase, instalment and leasing transactions ⁹.

These are areas in which firms within an industry may be expected to follow broadly similar accounting policies because of the similarity of asset composition and financing strategies pursued by these firms. A further inducement to uniformity of accounting policies may be the desire for comparability among firms in the same lines of business ¹⁰. Despite these a priori reasons uniformity is by no means an empirically established fact. Indeed in the U.S.A. Backer (1970) found from a survey of investment and credit analysts that even within the same industries firms pursued different methods of depreciation and goodwill amortisation ¹¹. This issue cannot, therefore, be conclusively resolved with the available evidence. However, since one of the weaknesses of inter-company comparisons using accounting data is said to be the lack of uniformity of accounting policies we shall assume that there is significant variation in accounting techniques both within and across industry groups ¹².

3.5.16. We now define descriptive ability for the purpose of this study as the ability of accounting ratios to differentiate firms in one industry from those in another in a statistically significant manner ¹³. The descriptive ability so defined will be demonstrated

9. See Statement of Standard Accounting Practice 2 on "Disclosure of Accounting Policies". The above list is not exhaustive but only illustrative.

10. Dearden and Shank (1975, p. 144) cite the 1968 U.S. Steel financial accounts in support of this motivation.

11. He found heterogeneous accounting methods in Oil Refining, Chemicals Steel and Utilities (p. 258) but uniform policies in Finance and Transportation (p.47).

12. See Backer (1970) and Westwick (1968).

13. The assumption is made that despite the imperfections of the industrial classification system used, viz. SEIC, industry groups are homogeneous. (See Section 2.2).

if the accounting ratios constituting a discriminating model that has statistically significant power to discriminate among industries are economically meaningful. Statistical significance is a necessary condition for the descriptive ability of the discriminating ratios. The sufficient condition is that they be also economically meaningful. In other words they must reflect some or all of the various industry dimensions discussed in Chapter 2 which determine the substantive attributes of firms' decisions. We believe that demonstration of descriptive ability as defined here will confirm that accounting numbers have significant informational content with regard to an important, though specific, class of substantive attributes of firms. This will enhance the utility of financial statements to financial and investment analysts and other users.

3.6. Conclusion

- 3.6. 1. In this chapter we have discussed the descriptive ability of accounting numbers as a criterion for evaluating the usefulness of accounting numbers and argued that it was superior to the other criteria proposed in the literature such as predictive ability and perceived utility. We have operationalised the criterion for the purpose of our study as the ability of accounting numbers to differentiate firms in one industry from those in another in a statistically significant and economically meaningful manner. If our analysis confirms the descriptive ability of the financial ratios studied in accordance with our definition it will demonstrate the informational content of accounting numbers with respect to an important class of substantive attributes of firms in the U.K. We shall examine the results presented in Chapters 7 to 9 with a view to assessing whether accounting numbers do possess descriptive ability with regard to these attributes or not. We have established the conceptual framework of our thesis in the last two chapters. We shall in the next chapter undertake a review of the related extant literature and place the present study in perspective.

Chapter 4

Review of Relevant Empirical Literature

4.0. Introduction

There have been many studies which have sought to identify or establish the structural relationship between the various industry dimensions described in Chapter 2 and the financial performance and structure of firms. In this chapter this extant literature is briefly surveyed. As the majority of work in the area has been carried out in the U.S.A. in the following pages unless specifically mentioned the reference is to an American study. The small amount of work that has been reported in the U.K. to date, however, is also reviewed. The chapter is concluded with a discussion of the nature and scope of the present research which are contrasted with those of the previous studies.

In the literature one may discern two broad approaches to the examination of inter-industry differences in the observed financial characteristics of firms. These approaches are characterised by different analytical aims. One is concerned with identifying a systematic industry factor in the determination of stock prices and its chief motivation comes from the investment analyst's search for rules to diversify his portfolio. If different industries exert different degrees of systematic influence upon stock prices then portfolios composed of stocks from different industries are likely to have much less variability of returns than otherwise. We shall refer to this approach as the investment analyst's or simply, the "investment approach".

The other approach is concerned with relating the outward financial characteristics of firms such as profitability and operating leverage to the underlying economic factors at work in an industry without reference to their valuation in the stock market. This analysis seeks to find economic meaning behind financial variables within the framework of industry. This approach will be referred to as

the financial analyst's or the "financial approach". The investment and financial approaches are, as may be anticipated, overlapping. The latter is a type of fundamental analysis and is bound to have implications for investment analysis to the extent that investment analysts use fundamental company characteristics in determining their investment strategies.

4.1. Industry as a Factor in the Determination of Stock Returns

4.1. 1 The assumption that industry is a determinant of stock returns implies that firms within the same industry are homogeneous with respect to those returns while their returns will be uncorrelated or negatively correlated with the returns of firms in other industries.

Conversely, the presence of uncorrelated or negatively correlated returns as between groups of firms belonging to different industries is an indication of the existence of distinct industry groups. In his attempt to construct optimal portfolios, Farrar (1962) sought to identify groups of industries which were mutually uncorrelated. On the basis of a factor analysis of monthly stock prices he found (p.52) that only two out of eleven four-digit industries were distinct which suggested an absence of systematic industry influence on stock prices. His conclusion is, however, not sustainable due to the nature of the data and the various methodological weaknesses¹.

4.1. 2 King's (1966) study is based on a taxonomic approach using both factor analysis and cluster analysis². He analysed monthly changes in the log price of 63 securities drawn from 6 two-digit industries, Tobacco, Petroleum, Metals, Railroads, Utilities and Stores for the period June 1927 to December 1960. Basing his analysis on the 3 factor model described in Chapter 2 he calculated that the market

1. Some of these are: 1) the use of prices and not returns leading to a high degree of serial correlation 2) the use of industry indices 3) the use of a very narrow industrial classification (4-digit) and 4) the use of the factor analytic technique which is not strictly appropriate.

2. On factor analysis see Child (1976) and Harman (1976). A brief description of the technique is provided in Appendix 6.1. On cluster analysis see Everitt (1974).

factor (the first factor) explained 58% of the total variance for the first six-year period although its importance declined to 31% in the last 6 year period. Industry factors explained, on average, 10% of the variance and were much more stable over time than the market factor.

- 4.1. 3 Meyers (1973) surmised that both King's sample and his empirical techniques resulted in an overstatement of the role of the industry factor and repeated King's study with two similar samples but slightly modified cluster and factor techniques. His results generally supported King's observation that industry relationships were an important source of inter-dependence among securities ³. Livingston (1977) tested King's claims of strong industry factors and Meyers' claims of weak industry factors by replicating their studies using similar samples and comparing the market factors (i.e. the first factor or component) resulting from the two studies. He found that King's market factor resembled the Standard & Poor (S & P) index very closely whereas Meyers first factor did not. He, therefore, concluded that King's results were more reliable.
- 4.1. 4 Livingston also performed a correlation analysis of the residuals of the regression of monthly rates of return for 734 firms in 100 industries on the S & P Composite index for the period January 1966 to June 1970. The results indicated "very strong evidence of the positive within-industry comovement after removal of market" (p.868). He estimated that the maximum residual industry effect was approximately 18% of the total variance as against 23% for the market. On the basis of his results he concluded that security analysis of industry groups as practised traditionally, made sense and that the "industry movement of securities must be accounted for in , diversifying one's portfolio" (p. 873).

3. For a criticism of some aspects of Meyers' study see Livingston (1977) who views the use of factor analysis for this purpose as inappropriate. Additionally, the use of Principal Components Analysis (PCA) by Meyers as against factor analysis by King is also inappropriate since PCA assumes that unique variance (which in this context would be due to firm-related factors) is zero.

- 4.1. 5 Fertuck (1975) sought to determine the appropriate level of aggregation for studying industry effects. Using cluster analysis based on the correlations of residual stock returns (i.e. after allowing for the market effect) he calculated that for some 3-digit industries the industry factor would account for up to 11.5% of the variance in monthly returns whereas for some others it would be as little as 1.4%. Also, the use of one and two-digit codes explained less than 3% of the variance in returns. For comparison, the market index explained about 25 to 30% of the variance. His results are thus broadly in agreement with the previous studies as to the relative importance of the market and industry factors.
- 4.1. 6 In the U.K. Russell and Taylor (1968) and Newport (1974) have investigated the industry effect on stock returns. Russell and Taylor grouped 50 industry indices according to their half-yearly returns over the period 1962 to June 1967. The groups were extracted by inspection of the correlation matrix of returns. They found one large group, three smaller ones and four outliers. The groups were difficult to interpret. The inconclusive results of this study may in part be due to the use of summary measures such as industry indices and to the small number of observations of returns.
- 4.1. 7 Newport (1974) performed both PCA and cluster analysis on his data of weekly and monthly changes in log prices for a sample of 60 companies drawn from 6 industries. His first component, the market factor explained 20.7% of the total variance compared to about 31% to 35% in King (1966) and Meyers (1973) 23% to 28% in Livingston (1977) and about 23% in Fertuck (1975). The remaining 6 components explained a further 17.2% of the variance and indicated rather weak industry groupings.
- 4.1. 8 The relevance of industry analysis to security evaluation was investigated by Joy (1974) who generated two series of returns from two portfolios constructed using a) a non-industry approach and b) an industry analysis approach. The price relatives generated ⁴

4. defined as $\frac{(\text{Price} + \text{dividend})}{\text{Price}_t} \cdot \frac{t+1}{t}$ where t is time.

by the two portfolios were then compared using various risk measures. Joy concluded that industry analysis did not enhance portfolio performance either before or after risk considerations ⁵.

4.1. 9 Differences among industries in the context of the systematic risk or "beta" of firms have, however, been demonstrated by Rosenberg and Guy (1976). Such differences are, of course, economically meaningful. As a result of differences among the declining, stable, growth and monopolistic industries the industry average levels of systematic risk may be expected to vary significantly. Fabozzi and Francis (1979) tested for the industry effect on 1128 American firms by regressing the firm betas on leverage, size, dividend payment record and a dummy variable to represent industry concerned. Their results showed that while their 4-variable model had a 33.4% explanatory power (i.e. the coefficient of determination) the incremental explanatory power attributed to industry effects was about 16% which was statistically significant. The study thus provides evidence that "significant industry-related effects can either increase or decrease the systematic risk of the stocks in any particular industry" (p.71).

4.1. 10 We may now summarise the foregoing stock market-related studies by noting:

- 1) that the evidence in favour of industry influence on stock prices, returns and betas is pre-ponderant ⁶ and

5. Joy's study can be criticised on at least three grounds:

- 1) his stock selection criterion is only one of several possible
- 2) no statistical test of significance is provided and
- 3) the effect of industry on the price/earnings ratio is not directly tested for.

6. Although this influence was not convincingly demonstrated in the studies of Farrar (1962) and Joy (1974) we have pointed out in our discussion that methodological considerations may have detracted from the strength of their conclusions.

- 2) that there is clear evidence that in some industries the industry effect is much stronger than in others ⁷.

Industry is thus an important determinant of the stock market risk-return characteristics of firms. We now turn to those studies which are concerned with the relationship between industry and the financial structure of firms.

4.2. Industry as a Determinant of the Financial Structure and Performance of Firms

- 4.2. 1 We have seen that in the stock market performance of firms there is a systematic pattern reflecting the influence of their industries. What rationale is there for anticipating a corresponding industry influence upon the financial structure and performance of firms? There is both theoretical and empirical support for the contention that a concept of earnings is related to market valuation (Van Horne, 1977). We have referred in the last section to studies which sought to explain stock market systematic variance in terms of financial variables (see paragraph 4.1.9). Beaver, Kettler and Scholes (1970) showed that beta coefficients could be predicted using a few financial ratios such as the dividend payout ratio, financial leverage and a measure of earnings variance. Similarly, Hamada (1972) established both theoretically and empirically the influence of financial leverage on betas.

- 4.2. 2 Indeed, it is plausible to hypothesise that industry influence will be much more strongly evidenced in the financial structure of firms than in their stock market risk and return profiles. The reason is that the financial structure of firms is directly affected and determined by various factors such as present and future product demand, production technology etc. as argued in Chapter 2. It is probably true to say that the direction of flow of industry influence is from the firm's financial structure and performance to

7. This may be explained by Farrell's (1974) finding that firms may also share characteristics such as growth, cyclical variation and stability which might transcend their industry affiliations.

market evaluation. To the investor the financial structure and temporal changes in it are the source of authentic signals concerning the direction, the nature and the extent of the impact of industry.

4.2. 3 Among all the financial characteristics of firms the one that has received the most attention in the literature is earnings. The accent on earnings is, of course, derived from the economist's and the investors' interest in profitability of which earnings are an essential component. Brown and Ball (1967) studied the association between the earnings of a firm, its industry and the economy using a sample drawn from 10 industries each containing 15 or more firms. By means of regressions of firms' earnings on market and industry earnings (Standard & Poor 2-digit industries were used) they found that:

- 1) on average, approximately 35-40% of the variability of a firm's annual earnings numbers can be associated with the variability of earnings numbers averaged over all firms and
- 2) on average, a further 10-15% can be associated with the industry average.

These results are consistent with those for stock returns obtained by King (1966) (see paragraph 4.1.2).

4.2. 4 Brealey's (1971) study of the comovement of American company earnings employed broadly the same methodology as Brown and Ball but used the first differences in logarithms of annual earnings as variables. His results displayed wide variation in the market and industry effects across industries.

"Companies in industries characterised by very homogeneous products such as cement, paper, oil, super-markets and tyres appear to have been most subject to an industry effect. In those industries where there is a diverse range of products or where products are distinguished by strong brand loyalties the industry influence is... relatively weak. This is the case with aircraft, cosmetics, drugs and office machinery group". (p.187)

- 4.2. 5 Magee (1974) repeated the regression analysis of Ball and Brown but his sample was drawn from more narrowly defined 4-digit industries since the 2-digit classifications used by Ball and Brown were "too broadly defined to capture the commonalties in earnings between firms in the same industry" (p. 271). He compared the explanatory power of a regression of firm earnings on a market index along with that of a regression on both a market index and an industry index. He found that the multi-index model added significantly to the single index model. In fact the average value of R^2 for the market index model was 0.1848 while that for the combined market and industry index model was 0.3468, an increment of 0.1620. Magee concluded that we could expect "a higher degree of commonalty when industries are more narrowly defined" (p.286).
- 4.2. 6 The studies of Ball and Brown, Brealey and Magee used the same statistical methodology although they differed in terms of sample size and the type of indices used to represent the market and the industry. The time period covered by Magee forms a sub-period of the period covered by the other two studies. The estimated industry effect ranged from 10-15% in the case of Ball and Brown, to 16.2% in the case of Magee to 21% in the case of Brealey. Despite their differences the three studies point to a fairly convincing presence of an industry effect. Moreover, they also indicate that this effect varies from industry to industry.
- 4.2. 7 Inter-industry differences in the levels and variability of profit rates were studied by Smyth, Briscoe and Samuels (1969) using aggregate industry returns for sixteen United Kingdom industry groups. They regressed 15 annual pre-tax returns on capital employed on both time and average profit rate in the manufacturing sector as a whole to take account of time trends and the effects of the overall economy. The average profit rates of the previous year and the following year were included as independent variables. The regression model's explanatory power (R^2) varied from 0.42 for Clothing and Footwear to 0.99 for Mechanical Engineering. The residuals from the regressions when analysed for specific industry-related cyclical pattern in profits revealed some anticipated patterns in certain industries.

- 4.2. 8 Studies by Singh and Whittington (1968) and Whittington (1971) form a single family in terms of data, techniques and objectives. Both of them used identical data viz. the financial accounts of U.K. firms for the period 1948-60. Singh and Whittington studied the relationship between the growth, size and profitability of the firms in four industries. They concluded that these industries differed in a statistically significant way in terms of the size mobility of firms within each industry and also in terms of the strength of relationship between growth and profitability. Whittington (1971) found that industries differed in terms of the ability of their constituent firms to maintain their relative profitability levels over time.
- 4.2. 9 Elton and Gruber's (1971) study was taxonomic in approach. They performed a cluster analysis on a sample of 180 firms representing 44 traditional SIC four-digit industries based on the orthogonal principal components of a variable set of 15 annual growth rates in earnings per share. Ten clusters resulted and were named pseudo-industries. Comparison of traditional and pseudo-industries showed that firms in the former were widely dispersed across the pseudo-industries (see their table on page 443). Forecasts of earnings per share for one year ahead based on regressions of historic earnings per share on a number of corporate variables were made for traditional and pseudo-industries. Forecasts based on pseudo-industries were statistically better than those based on traditional industries at 0.1% level thus suggesting that at least with respect to earnings' growth traditional industries were not homogeneous.
- 4.2. 10 There are some methodological issues in the study that deserve comment. The conclusions are based on only one year's forecast. The dependent variable, earnings per share growth was the same as that upon which the firms were clustered. It is, therefore, not surprising that pseudo-industries provided the superior framework for forecasting earnings. It is indicated (p.440) that regressions of earnings growth on the financial variables even within the traditional industries were statistically significant which means that the traditional industries were not entirely non-homogeneous. The

extent of homogeneity could not, however, be assessed in the absence of R^2 values in the published paper. For these reasons traditional industries cannot be dismissed as an inconsequential framework on the basis of the reported results.

- 4.2. 11 Another study based on a cluster analytic approach is that by Gupta and Huefner (1972). They grouped two-digit industries in a univariate manner on each of four financial ratios separately viz: fixed asset turnover, inventory turnover, average collection period and cash velocity. The validity of the resulting groupings was assessed by comparing them with those provided by industrial economists and by analysing the underlying economic characteristics. They claimed that cluster analysis groupings of the ratio data corresponded with both the judgmental classifications of economists and with numerous qualitatively expressed economic characteristics of the industries involved.
- 4.2. 12 This American study, however, suffers from serious data and methodological limitations which must realistically largely vitiate its conclusions for our purposes. As the data were drawn from twenty 2-digit SIC (Standard Industrial Classification) industries in aggregate no conclusions can be drawn about individual firms. Moreover, the univariate nature of the study and the high apparent correlations among the ratios used limit the significance of the study⁸.
- 4.2. 13 In an earlier study Gupta (1969) related qualitative industrial features such as opportunity for fabrication, fixed asset composition, organisation structure, labour intensity, perishability and unit value of the products etc. to turnover, leverage, liquidity

8. Further limitations of the study are:

- 1) the criterion used to determine the number of clusters is arbitrary with the result that some of them are economically meaningless. Since 2-digit industries already represent the highest level of aggregation and can, therefore, be expected to be homogeneous restricting the number of clusters to four inevitably leads to meaningless clusters e.g. Food, Electrical Equipment and Textiles in the same cluster (p.85).
- 2) the study does not define all the financial ratios used.

and profitability ratios using aggregate data covering twenty SIC two-digit industries. The data related to the year 1961-62. The author claimed some degree of correspondence between the industry features and the ratios. However, this study is again methodologically very weak. Indeed it is not even clear what the methodology was that was employed to study the inter-industry differences. No statistics characterising these differences are reported and no test of statistical significance appears to have been carried out. It is, therefore, difficult to draw firm conclusions from the study. As in the case of the Gupta and Heufner study the univariate approach of the study is a further limitation.

- 4.2. 14 Jones and Ferri (1979) tested the hypothesis that differences across industries in the volatility of income, the amount and kind of current assets needed, the relative importance of fixed assets to the production process and trade credit practices would induce differences in short term leverage across industrial groups. The association between two measures of short term leverage, short term debt/total assets and short term debt/networth and industry classes was tested by means of Kruskal-Wallis H-statistics⁹ for the years 1974 and 1976. The test results were statistically significant. Thus there was evidence of

"substantial differences in the use of short term leverage among industrial groups. Moreover, these industry distinctions persisted in the face of substantial changes in the external economic environment" (p.24).

- 4.2. 15 Ferri and Jones (1979) also studied inter-industry differences in the longterm leverage of firms using both four-digit industries and generic groupings of those industries based on dominant product lines. The data related to the years 1969-76. The firms in the sample were initially clustered into homogeneous leverage classes. Twenty-five SIC industries as well as generic industry groups were

9. See Siegel, S. (1956).

cross-tabulated with leverage classes for both 1974 and 1976. On the basis of calculated asymmetric uncertainty coefficients ¹⁰ it was found that leverage class could be better predicted with SIC codes than with generic industry groupings.

- 4.2. 16 All the foregoing studies have been univariate in so far as they have sought to establish inter-industry differences in terms of single financial variables such as stock returns, earnings change, asset turnover etc. However, industry as pointed out in Chapter 2 has multiple and complex dimensions. It may, therefore, be expected that the interaction between these dimensions and firms is unlikely to be captured by any single facet of the financial structure of firms. A better approach would, therefore, be a multivariate one.
- 4.2. 17 Following this reasoning, Martin et al recently (1979) attempted a multivariate definition of business risk. They argued that the traditional assumption of the equivalence between industry class and business risk did not adequately take into account the multidimensional nature of business risk. They defined business risk in terms of the firm's:
- 1) competitive position within its industry
 - 2) cyclical variability of sales
 - 3) operating leverage
 - 4) size
 - 5) growth potential and
 - 6) product differentiation.

A sample of 290 firms was clustered into homogeneous risk classes on the basis of the above six measures. The risk classes so found were compared to the traditional industry classifications of the participant firms. A high correspondence between the two sets of groups could have been used to justify the assumption that traditional industry groups were homogeneous with respect to business risk. It was, however, found that firms in traditional industry groups were dispersed across the empirically identified business risk classes.

10. This statistic indicates the degree to which knowledge of the independent variable (e.g. SIC code) reduces error in predicting the value of the dependent variable (e.g. leverage class). For further details see Ferri and Jones (1979).

4.2. 18 Although on a superficial view the above result may seriously call into question the use of the conventional industry classification system to provide homogeneous risk classes it must be noted that the small sample of 290 firms was clustered into 174 risk classes! That is each firm was nearly a risk class by itself. There were 115 single firm clusters, 27 clusters with two firms and 18 clusters with three firms. There was only one cluster each with six, seven and eight firms. The inability of the study to find larger and fewer clusters may be due to the variables used to define business risk which may be highly firm oriented and not sufficiently industry-oriented. The results of the study must, therefore, be treated with some misgiving.

4.3. The Discriminant Analysis Approach to Inter-industry Differences in Financial Structure

4.3. 1 In the cluster analysis procedure used by Martin et al a given set of variables was used to construct groups which were homogeneous within but differentiated without from other groups. In discriminant analysis this process is to some extent reversed. Starting with a given set of groups the given variables are combined in such a way as to differentiate the groups best. The combination is called the discriminant function. Depending upon the number of groups and the number of variables there may be more than one discriminant function. The power of the discriminant model is measured by its ability to discriminate between the groups, in other words, by how accurate it is in classifying the members of the groups (a more detailed discussion of discriminant analysis is provided in Chapter 7).

4.3. 2 Williams and Goodman (1971) used linear discriminant analysis to determine how well 14 selected stock market and accounts-based variables would differentiate

- 1) between utility and industrial companies and
- 2) among chemicals, drugs, domestic oils, steels and electronics industries.

These industries were defined in terms of the main product of the companies assigned to them. The data related to the period 1946-67. The two group discriminant model in the case of utilities and

industrials was statistically highly significant (as measured by the Mahalanobis D^2 and the corresponding F-statistic) in both the years 1966 and 1967 and was able to correctly re-classify 98% of the firms in the original sample ¹¹.

- 4.3. 3 A five-group linear discriminant model was constructed for each of the 22 years studied to discriminate among the five industries referred to above. On an average, 72% of the original sample of firms was correctly classified and the model was statistically significant. When one year's model was used to classify the firms using next year's data (i.e. the model was used in a predictive sense) the percentage of correct classification fell on average to 60%. The above results would appear to indicate a high degree of homogeneity among the industry groups studied with this homogeneity persisting over time. However, a number of caveats must be made:
- 1) the variables used were a mixture of financial structure and stock market related measures (seven of the fourteen had either the stock price or volume of trading as a component).
 - 2) the statistical assumptions underlying discriminant analysis were not rigorously tested for.
 - 3) the variables used were heavily biased in favour of earnings and related measures to the exclusion of the other financial dimensions of firms.
 - 4) it is not clear how far the industrial classification used corresponds to SIC classification.
 - 5) a high degree of multicollinearity and function overfitting was present and finally
 - 6) the use of the original sample for validation of the derived discriminant functions is subject to severe criticism ¹².

- 4.3. 4 A much more detailed analysis of inter-industry differences using linear discriminant analysis and the study most similar to our approach was that conducted by Eugene (1977). He analysed the inter-industry variation as well as the within-industry homogeneity of ten 2-digit industries covering in broad terms processing, manufacturing and retail

11. See Eisenbeis and Avery (1972) on the statistics referred to and Chapter 7 on the problems of assessing classification accuracy.

12. See footnote 11. This criticism is, however, mitigated by the use of subsequent years' samples to test the models.

firms numbering one thousand and sixteen. Discriminant functions were derived for each year 1970, 1971 and 1972. The sample was split into two, one half being used to derive the discriminant functions (the analysis sample) and the other used as a cross-validation or holdout sample. The three models correctly classified, on an average, 40% of the analysis sample and 47.5% of the holdout sample. Since chance classification would yield less than 10%, the models are statistically highly significant. The individual industry classifications indicated that process-type industries were generally more homogeneous than the other industries.

4.3. 5 Eugene also reclassified the 10 industries into 3 "super-industries" processing, manufacturing and retail and repeated the discriminant analysis. The results showed that processing and manufacturing firms were correctly classified at rates in excess of 64% in each of the three years, while the retail industries had a classification rate of 30% in 1970 which improved to 52% in 1972 indicating probable sample bias. Comparison of classificatory accuracy for the 3-group model with that for the 10-industry model showed that aggregation resulted in greater homogeneity, the effect of diversification probably having been lost. The different discriminant models included from 14 to 29 ratios many of which appear to be highly correlated (p.116). The relative importance of these ratios was not indicated by Eugene. Ratios relating to asset structure, current assets and asset turnover were generally consistent discriminators and also statistically highly significant on a univariate basis.

4.3. 6 Eugene analysed the stability of the discriminatory power of the ratios over time by:

- 1) comparing the ratios included in the models for the years 1971, 1972 and 1973 and
- 2) using the models to predict the industry membership of firms based on the data for 1974 and 1975.

He found that the ratio composition of the three years' discriminant models was similar. When used to predict membership of firms in 1974 and 1975 the models achieved rates of classificatory accuracy comparable to those obtained for the analysis and holdout samples further confirming the inter-temporal stability of the ratios as

discriminators. By repeating the same analysis with 4-digit industries as with the 2-digit industries Eugene concluded that different industries were homogeneous at different levels of aggregation.

4.3. 7 Eugene's study, unlike Williams and Goodman's (1971) relied entirely on financial statement variables. It provided evidence of the informational content of accounting numbers in so far as they could distinguish among different SIC industries. There are, however, many methodological shortcomings detracting from the validity of the study among which are:

- 1) the problem of interpretation of the discriminant functions since they included an unwieldy number of ratios. This problem is accentuated by the fact that these ratios were highly inter-correlated.
- 2) because of the number and redundancy of the discriminant ratios the study does not clearly indicate the relative importance of the ratios ¹³
- 3) no test of the underlying assumptions of multivariate normality and equality of dispersion matrices was undertaken
- 4) only linear classification rules were employed and quadratic classification was not attempted
- 5) the split sample validation method used is inefficient ¹⁴. The classification results are, therefore, not highly reliable and
- 6) it lacks a rigorous examination of the extent of diversification and integration among the sample firms.

4.4. Summary of Review and Scope of Present Study

4.4. 1 In this chapter we reviewed the extant literature on industry influence on firms in the context of such stock market parameters as expected returns and systematic risk and also in terms of financial characteristics such as profitability as embodied partly or wholly in the financial structure of firms. The literature has provided empirical support for the a priori belief that industry has a

13. For a discussion of the issues involved in this connection see Chapter 7.

14. See Eisenbeis (1977, p.894).

distinct and measurable impact causing firms in different industries to have different financial structures and stock market risk-return profiles. Especially relevant to the present research is the demonstration that certain financial ratios are capable of differentiating among industries.

- 4.4. 2 The review has revealed a disturbing lack of U.K. based studies of the industry impact on the overall financial structure of firms. The only notable U.K. based studies have been those of Singh and Whittington (1968), Whittington (1971), Newport (1974), Smyth et al (1969), but they provide a very narrow focus being concerned either with profitability or stock returns. The U.S. studies cited above indicate that inter-industry differences are more likely to reside in asset structure (Eugene (1977) see paragraph 4.3. 5 ante). The previous U.K. studies have ignored the interaction between the multidimensional aspects of both the firms and the industries.
- 4.4. 3 Among the studies which attempted to analyse the relationship between the multiple dimensions of firms' financial structure and the different characteristics of their industrial environment, Gupta (1969) and Gupta and Heufner (1972) were univariate. In addition to this limitation these studies also had several other methodological weaknesses (see paragraphs 4.2. 11 - 4.2. 13). Williams and Goodman (1971) and Eugene (1977) by employing discriminant analysis overcame the limitations of the univariate approach. Their studies, however, also suffered from both data and methodological shortcomings as detailed in paragraphs 4.3. 3 and 4.3. 7 which tend to detract from the validity of the conclusions that may be drawn.
- 4.4. 4 In our study we have endeavoured to overcome the shortcomings in the extant work. Although our study has similarities with some of the previous studies it has much wider conceptual and methodological scope.
- 1) It places the implications of the results for accounting theory and techniques in perspective.
 - 2) It has a multidimensional focus.
 - 3) It extends the scope of previous research using discriminant analysis by testing the data more rigorously for the relevant statistical assumptions and by performing both linear and

quadratic analyses.

- 4) It uses an industrial classification system which is widely used by the investment community in the U.K. and, therefore, has important implications for that community.
- 5) Unlike most previous studies it uses only financial statement variables and
- 6) it examines empirically the validity of assumptions underlying the use of financial ratios.

4.4. 5 In the next chapter we address two of the fundamental methodological issues raised in this chapter and referred to in Chapter 1.

- 1) We empirically test the validity of ratio transformation of accounting numbers and
- 2) we examine the distributional properties of the ratios in our data to determine whether they satisfy the normality assumption that underlies the discriminant models presented in Chapters 7 to 9.

The selection criteria and other issues in the construction of our samples are also discussed in the next chapter. The discussion and testing of the dispersion equality assumption will be taken up when the discriminant models are presented in Chapters 7 to 9.

Chapter 5

The Data and the Related Issues

5.0. Introduction

In Chapter 3 we proposed descriptive ability of accounting numbers as an essential condition for the usefulness of accounting statements. Our test of descriptive ability for the purpose of this study was set up in terms of financial ratios for the reason that ratio transformation of raw accounting numbers was, as stated in paragraph 1.2. 1, the most widely employed approach to financial statement analysis. Although widely used, this approach raises many methodological issues which have not until now received much empirical attention in the literature.

"It appears that the extensive use of financial ratios by both practitioners and researchers is often motivated by tradition and convenience rather than resulting from theoretical considerations or from a careful statistical analysis" (Lev and Sunder, 1979, p. 187).

In this chapter we discuss the conditions under which ratio transformation is valid and the consequences of deviation from these conditions. A major consequence is the possibility of "spurious correlation" between ratios having common deflators. Our data were tested for conformity with the conditions for valid transformation and the results are presented.

Conformity of our data with the multivariate normality assumption required by the discriminant models presented in Chapters 7 to 9 is investigated in this chapter. We examine in detail the statistical distribution of the ratios included in our data set. In the literature, several transformations of data have been suggested as a means of improving normality of distribution. Some of these are examined in this chapter with a view to selecting the "best". The criteria for deciding on the best transformation are stated.

We also describe the criteria used in the construction of our sample of firms and ratios. A striking feature of present day financial analysis is the plethora of financial ratios used by practical analysts and academic researchers. Although many of these ratios are related and, therefore, possibly redundant analysts and researchers often argue for the superiority of some ratios over others on the basis of the supposed additional insight they provide into the conditions of firms. We have taken account of the rival claims for different ratios in compiling our variables and our ratio set is accordingly quite large. We investigate the possible redundancy in these ratios in the next chapter.

5.1. Sample Selection

- 5.1. 1 Data used in the present study consist of two samples made up of
- 1) firms in the manufacturing sector and
 - 2) firms in the wholesale and retail distribution (hereafter, distribution) sector.

The period from which the accounting data were drawn extends from 1st May 1972 to 30th April 1978. All the firms in the samples are or were quoted on the London Stock Exchange (LSE). The data were extracted from the EXSTAT computer tape available from Extel Statistical Services, London. The tape contains the balance sheets and profit and loss accounts for over 2000 quoted and unquoted, U.K. and foreign firms. The firms we are concerned with in this study are 70% of the most actively traded quoted companies. EXSTAT is a very powerful data base and this is one of the first studies to make use of this new data source.

- 5.1. 2 Firms available on the EXSTAT tape are only a segment of all the firms quoted on the LSE. They are, however, the most actively traded stocks. The use of the EXSTAT tape as our data source is to some extent restrictive in regard to both the absolute size of our samples and their composition. The samples are made up of the relatively larger firms. We justify this on the following grounds:
- 1) since the main focus of this study is the place of inter-industry differences among firms in financial analysis it was thought proper to confine our data to firms which are of interest to the

financial and investment community

- 2) there is a sufficiently wide range of size among the firms in the samples (e.g. in 1972-73 total assets of firms in our samples ranged from £835,000 to £3,395 millions). Thus the exclusion of small companies is unlikely to affect the results to any significant degree and
- 3) the inclusion of very small firms might indeed have made our samples less homogeneous.

Firms in the EXSTAT data base are classified according to the Stock Exchange Industrial Classification referred to in Section 2.2.

5.1. 3 Companies which could not be regarded as either manufacturing or distribution were excluded from the samples. The industries so excluded are:

- 1) service industries - e.g. Laundries and Cleaners, Agencies etc.
- 2) Transport, Freight and Fuel
- 3) Hotels and Caterers
- 4) Leisure
- 5) Financial Trusts, Investment Trusts, Banks etc.
- 6) Commodity Traders
- 7) Construction
- 8) Newspapers and Periodicals and
- 9) Publishing and Printing

However, companies in the Leisure and Miscellaneous industry classes were screened for substantial manufacturing activity and 13 companies from these were included in the manufacturing sample.

5.1. 4 The following industries were excluded from the manufacturing sample because of the high content of excise duties in their reported sales figures which, it was considered, would distort comparison with firms in other industries:

- 1) Breweries
- 2) Wines and Spirits and
- 3) Tobacco

The industries in the final sample are listed in Appendix 5.1.

5.1. 5 There is no externally available criterion for assigning companies to the manufacturing and distribution sectors. Moreover, vertical integration of the activities of firms makes the distinction between manufacturing and distribution rather arbitrary. Our criterion was

to classify those firms with more than 50% of their activity in manufacturing, as manufacturing and those with less as distribution firms. A detailed examination of the sectoral distribution of firms' sales was undertaken using the Extel British Company Service annual and news cards. Firms with more than 50% of their turnover attributable to their manufacturing activity were classified into the manufacturing sample.

- 5.1. 6 Time Span of Data: Since one of our objectives was to examine the temporal stability of inter-industry differences, analyses of data relating to six annual periods was undertaken. For this purpose the annual period employed was the year running from 1st May to the following 30th April. Thus the first year of our analysis was the period 1st May 1972 to 30th April 1973 and the sixth year was the period 1st May 1977 to 30th April 1978. For convenience the first year is referred to as 1972, the second as 1973 and so on. Since the majority of companies have annual year ends falling between the 31st December and 30th April our definition of "year" has the advantage over the calendar year that the accounts analysed in each year will relate substantially to the same period.
- 5.1. 7 Our final samples consisted of 570 manufacturing companies and 201 distribution companies for the years 1972-75. The manufacturing sample for 1976 had 569 firms, one of the firms having ceased trading. But owing to a number of firms ceasing trading in 1977 the manufacturing sample was reduced to 528 and the distribution sample to 193 (including 10 new companies). The companies in the manufacturing and distribution samples are listed in Appendices 5.2 and 5.3.

5.2. Selection of Ratios

- 5.2. 1 Financial ratio analysis is a diagnostic process in which ratios are regarded as "symptoms". Using financial ratios inferences concerning the condition, performance and state of health are drawn. However, the financial literature lacks any coherent theory establishing a causal relationship between the condition of a firm and its financial ratios. In the absence of a theory of financial ratios one has to fall back upon:

- 1) a priori argument in the literature supporting the use of certain ratios and
- 2) the empirical usefulness of ratios demonstrated by previous studies.

5.2. 2 Taffler (1976) compiled a set of 80 ratios by reference to the previous studies of Beaver (1966 and 1968), Altman (1968), Horrigan (1966), Edminster (1972), O'Connor (1973), Jaedicke and Sprouse (1965, Ch.VII), Sorter and Benston (1960) and Davidson et al (1964) and by consultation with investment analysts in the City. His compilation was, however, carried out in the context of a discriminant analysis of failed and non-failed firms in the U.K. For the purpose of the present research all his ratios would not necessarily be appropriate. His ratio set was, therefore, examined and 29 ratios which were thought to be redundant were excluded.

5.2. 3 From the literature reviewed in the last chapter additional ratios which might be more relevant to the present enquiry were selected and added to the ratio set. A major objective in the selection of ratios was to represent as many facets of firms as possible that can be calculated from their published financial statements. In broad terms the selected ratios represent

- 1) operating and profit performance
- 2) financial risk
- 3) operating risk
- 4) activity
- 5) liquidity and
- 6) dividend policy

As argued in Chapter 2 and evidenced in Chapter 4 some or all of these dimensions of firms may be expected to be affected by the industry environment.

5.2. 4 Based on the above selection criteria a set of 82 ratios was constructed. In addition five absolute size measures were included in the set. Size may be a function of industry for two reasons. Firstly, the requirements of technology may impose a certain minimum scale limit on firms (see paragraphs 2.4. 6 - 2.4. 7). Similarly, in those industries in which there are economies of scale and a continuous production process the necessary heavy investment in

capital assets will result in the firms being, on average, large. Secondly, in oligopolistic industries the average size of firms is likely to be larger than in more competitive industries. The 82 ratios and 5 size measures are listed in Appendix 5.4. and their components and definitions are provided in Appendix 5.5. Although the size measures are absolute values we shall refer to them as ratios for convenience except where the context requires that their absolute nature be specified.

5.2. 5 The imperfections of accounting data are too well known to need more than a brief reference here. Because of the wide discretion given to firms in the valuation of assets, provision of depreciation, treatment of goodwill, treatment of government grants and deferred taxation and of bank overdrafts it is conventionally argued that the inter-firm comparability of accounting data may be diminished to a degree. The problems arising from the use of discretionary accounting by firms in the case of asset valuation are discussed by Singh and Whittington (1968, pp.218-221). Westwick (1968) argues that data drawn from the accounts of companies in accordance with the requirements of the 1967 Companies Act is next to worthless for inter-firm comparison. Van Horne (1980, pp.714-715) exhorts users of accounts to go beyond the reported figures and examine critically certain of the published data and admonishes that even with standardised figures considerable caution in interpreting any comparison results must be taken.

5.2. 6 It is, therefore, plain that reported figures need to be adjusted to make them comparable across firms. Such an adjustment exercise, however, may be restricted by the lack of requisite detail in published accounts. Nevertheless the data used in this research were adjusted to make the accounting numbers more meaningful and comparable. The adjustments made to standardise the published accounts are indicated below:

- 5.2. 7
- 1) Bank overdraft and cash are netted off.
 - 2) Quoted investments are included at market value. The excess (or shortfall) over book value is added to (or subtracted from) shareholders' equity.
 - 3) Intangible assets are excluded and deducted from shareholders' equity.

- 4) The deferred taxation account is treated as an equity item.
- 5) Corporation tax payable is classified as a current liability.
- 6) A quarter of the long term bank loans and hire-purchase outstanding is included in the current liabilities; this portion is arbitrarily regarded as being repayable within the short term and, therefore, a current liability for our purposes.
- 7) Government grants received are classified as long term liability.
- 8) Value added is calculated by adding employees' remuneration, earnings before tax, interest and depreciation and deducting any other income. This definition is not conventional but the best that can be obtained from the limited information on the EXSTAT tape. One further problem with this measure is that most companies do not report their overseas employees' remuneration.

5.2. 8 An important principle in the construction of ratios is that the two components of ratios must be logically related (see Benishay, 1971 for the discussion of this point). Ratios in our data set were constructed in accordance with this principle as far as possible. Where, however, a ratio has been extensively used in the literature or by analysts but contains seemingly illogical components it was nevertheless retained in order to preserve a means of comparing our results with those of previous studies. Certain defects of published accounts, were, however, quite ineradicable e.g. off-balance sheet financing, since the information necessary to facilitate adjustments was not available.

5.3. Rationale of Ratio Transformation of Accounting Data

5.3. 1 Elimination of Size Effect: Ratio transformation of accounting data is usually undertaken to achieve certain analytical objectives.

"The major objective of using financial variables in the form of ratios is to control for the systematic effect of size on the examined variables. Such size control underlies the most elementary use of ratios in corporate

financial analysis" ¹ (Lev & Sunder, 1979, p. 189).

Traditional financial analysis assumes that deflating the raw financial variables by a measure of size has the effect of removing the influence of size.

- 5.3. 2 Assumption Underlying Ratio Transformation: The basic assumption implicit in ratio transformation as a means of removing the effect of size is that the variable of interest is a homogeneous function of size to degree one. Under this condition the variable would change in proportion to change in the size variable. This relationship may be represented by the following equation,

$$Y = b X \quad 5.1$$

where X is the size variable and Y is a linear homogeneous function of X.

Then,

$$Y/X = b \quad 5.2$$

Under this strict proportionality condition the ratio Y/X is independent of X and the effect of size is completely eliminated. The ratio indicates both the marginal and average effects of a change in X on Y.

- 5.3. 3 Deviations from Proportionality: Lev and Sunder (1979)² discuss three types of deviation from proportionality where the relationship between Y and X is:

- 1) linear non-homogeneous of the form

$$Y = a + b X \quad 5.3$$

then

$$Y/X = a/X + b \quad 5.4$$

-
1. Some of the other objectives may be: a) to satisfy the assumptions underlying statistical models such as homoscedasticity in the case of regression b) to reduce the complexity of the relationship among variables which are in turn related to a common variable e.g., the trivariate relationship between dividends, earnings and cashflow may be reduced to a bivariate one between $\left(\frac{\text{dividends}}{\text{earnings}}\right)$ and $\left(\frac{\text{cashflow}}{\text{earnings}}\right)$ (Lev & Sunder, 1977).
 2. The discussion in this and the next paragraph is generally based on their paper. Also see Whittington (1980b).

2) non-linear of the form, say

$$Y = b X + c X^2 \quad 5.5$$

then

$$Y/X = b + c X \quad 5.6$$

3) stochastic of the form

$$Y = a + b X + e \quad 5.7$$

where e is the stochastic error term.

$$Y/X = a/X + b + e/X \quad 5.8$$

5.3. 4 Implications for Univariate Ratio Analysis: Equations 5.4 and 5.6 indicate that Y/X is still dependent upon X . Thus under conditions of non-homogeneity or non-linearity ratio transformation does not result in the elimination of the size effect. Moreover, under such conditions the ratio is a biased estimate of the marginal effect of a change in X on Y . When the relationship is non-homogeneous the bias is the larger the smaller the size of the firm and in the case of non-linearity of the form shown above the bias increases with size. The effect of the presence of the stochastic error term is, however, dependent upon the properties of the error term and the relationship between the error term and the size variable. In equation 5.7, X may be assumed to be non-random. The error term may be either homoscedastic or heteroscedastic. If it is heteroscedastic and variance, $\text{Var}(e) \propto X^2$ ratio transformation will result in homoscedastic error in equation 5.8. In all other cases whether the error is homoscedastic or otherwise the variance of the error resulting from ratio transformation will be a function of size. Since ratio transformation in these cases does not completely eliminate the size effect the resulting ratio may not be used for inter-firm comparison across firms of differing sizes.

5.3. 5 Implications for Multivariate Ratio Analysis: Ratio transformation under conditions other than strict proportionality has serious consequences also for multivariate ratio analysis. For example, suppose we are interested in studying the strength of relationship between return on equity and debt/equity which have the common deflator, equity and use the correlation coefficient as a measure of that relationship. The assumption behind the correlation exercise is that it measures the residual association between return and debt

after allowing for the effect of size, in this case equity. However, this assumption may not be valid where each ratio is in violation of the homogeneity condition. Depending on the extent of deviation from that condition the correlation between the two ratios may be an under or over-estimate of the "true" residual correlation which is the object of real interest. The ratio correlation in this case is then said to be a "spurious" estimate of the true residual correlation.

5.3. 6 Spurious ratio correlation potentially has an important bearing upon the results of a principal components analysis (PCA) of our data presented in the next chapter. This analysis was undertaken to identify the dimensionality of the data. It is based on the inter-correlations among the financial ratios and it is, therefore, necessary to determine whether and to what extent these ratio correlations are spurious. Significant spurious correlation will seriously undermine the validity of the results. Apart from its immediate relevance to the present study, the investigation of the problem of spurious correlation has considerable potential value to financial ratio analysis as a whole. In the financial literature the problem has aroused much - often misplaced - concern (see Lev and Sunder, 1979, p. 193) but little empirical attention. In the following section an empirical test of spurious correlation among ratios having a common deflator is presented. A mathematical formulation of the definition and conditions for spurious correlation is provided in Appendix 5.6.

5.4. Spurious Correlation between Ratios with Common Deflators

5.4 1 Definition of Spurious Correlation: The mere appearance of a deflator common to two ratios has given rise to the suspicion that the resulting correlation is of a spurious nature (e.g. Gonedes, 1973 p. 436). However, it is clear from the above discussion that spurious correlation is attributable directly to the violation of the homogeneity condition. The term "spurious correlation" implies a "true" correlation and a measure of spurious correlation is the degree of deviation from this true correlation. There is however, no general agreement on what constitutes "true" correlation. In the literature two approaches are

discernible. According to Pearson (1897) spurious correlation is the difference between the simple correlation of the undeflated variables and the correlation between the ratios formed by deflating them. He considered the case of the correlation between two ratios with a common deflator when the undeflated variables are themselves uncorrelated and derived a measure of this spurious correlation (see Appendix 5.6).

- 5.4. 2 Pearson's definition of spurious ratio correlation as the deviation of ratio correlation from the simple correlation of the undeflated variables has, however, some conceptual problems. The aim of deflation is to remove the effect of the deflator and the ratio correlation must, therefore, be compared to the residual correlation of the undeflated variables after allowing for the influence of the deflator. A measure of such residual correlation is the partial correlation of the undeflated variables holding the effect of the deflator constant. It is thus more appropriate to compare the ratio correlation with the partial correlation. Kuh and Meyer (1955), therefore, considered the divergence of ratio correlation from the corresponding partial correlation as the measure of spurious correlation and derived the condition under which the ratio correlation will be an unbiased estimate of the partial correlation with the deflator kept constant.

- 5.4. 3 Conditions for Non-spurious Ratio Correlation: Kuh and Meyer (hereafter KM) showed that the necessary and sufficient condition for the equality of ratio and partial correlations was that each of the undeflated variables be a linear homogeneous function of the deflating variable to degree one. Algebraically the relationship between the undeflated variables and the deflator must be of the form

$$X = b_1 Z \quad \text{and} \quad Y = b_2 Z$$

where Z is the deflator and X and Y are the raw variables. Under this condition the ratio correlation will be a non-spurious and unbiased estimate of the partial correlation. It will be seen that this condition is the same as that which underlies ratio transformation. Where it is not fulfilled ratio transformation is in theory inappropriate. As a result the statistical association between two ratios formed in violation of the homogeneity condition

may be a spurious estimate of the "true" association between two variables after allowing for the effect of the deflator. (For a mathematical formulation of KM's conditions see Appendix 5.6).

5.5. Empirical Test of Homogeneity and Spurious Correlation

5.5. 1 In this section we present the results of an investigation of the extent to which the homogeneity condition is satisfied by some of the ratios included in our data set and also of the degree of spurious correlation, if any, among them. The data analysed related to the 1976 sample of 569 firms and were untransformed. Satisfaction of the homogeneity condition will confirm the validity of ratio transformation. We also need to understand the circumstances under which deflation may lead to spurious correlation.

5.5. 2 The Test Methodology: Initially a set of ratios with a common deflator, Sales was formed. Sales is a measure of size commonly used in the financial and economic literature. The numerators were chosen from both balance sheet and profit and loss accounts. For each pair of numerator variables the following measures of association were calculated:

r_{xy} = coefficient of correlation between the numerators

r_{xz} , r_{yz} = coefficients of correlation between the numerators and the deflator (z).

$r_{\frac{x}{z}, \frac{y}{z}}$ = ratio correlation

$r_{xy.z}$ = partial correlation between the numerators with the effect of deflator held constant

$r_{\frac{x}{z} \frac{y}{z}.z}$ = partial correlation between the ratios holding the effect of deflator constant

These various measures of statistical association are used to investigate and explain the dichotomy between ratio correlation and partial correlation. The analysis is repeated for three other ratio sets with Total Assets (TA), Total Capital Employed (TCE) and Net Capital Employed (NCE) as deflators. The ratios used in the analysis are listed in Table 5.1.

1 TA/S	9 TL/TA	16 CA/NCE	22 CA/TCE
2 CA/S	10 CA/TA	17 QA/NCE	23 QA/TCE
3 QA/S	11 QA/TA	18 EBIT/NCE	24 S/TCE
4 TCE/S	12 S/TA	19 CF/NCE	25 EBIT/TCE
5 NCE/S	13 EBIT/TA	20 FF/NCE	26 CF/TCE
6 EBIT/S	14 CF/TA	21 S/NCE	27 FF/TCE
7 CF/S	15 FF/TA		
9 FF/S			

Key to ratio elements: TA = Total Assets; CA = Current Assets;
 QA = Quick Assets; TCE = Total Capital Employed;
 NCE = Net Capital Employed; S = Sales;
 EBIT = Earnings Before Interest and Tax;
 CF = Cash Flow; .FF. = Funds Flow;
 TL = Total Liabilities

Table 5.1: Ratios Used in Spurious Correlation Analysis

(for detailed definitions of the ratio elements see Appendix 5.5)

5.5. 3 Results of the Test of Homogeneity: To investigate whether the numerator variables have a linear homogeneous relationship with the deflators each numerator variable was regressed on the relative deflator. If the explanatory power of the regression as measured by the coefficient of determination (R^2) is very high a high degree of linearity is indicated and if the intercept of the regression is very small or statistically non-significant a homogeneous relationship is suggested. Results of our analysis are presented in Table 5.2. It can be seen that the deflator in each case has a high explanatory power since R^2 is uniformly high indicating a high degree of linearity. On the other hand, some of the numerator variables are non-homogeneous with significant intercepts. Earnings before Interest and Tax (EBIT) is the most homogeneous of the numerator variables while the least homogeneous are Current Assets (CA) and Quick Assets (QA). This position is also reflected in the ratio of intercept to the mean shown in the last column of Table 5.2. This ratio is a measure of the size of the intercept.

Numerator (Nr)	Deflator (Dr)	a	b	R ²	Mean of Nr (M)	a/M
TL	TA	-989 (0.044)	.5214	.96	32273	-.03
CA	"	2954	.5571	.96	38495	.08
QA	"	1423	.2842	.95	19557	.07
S	"	2841 (0.09)	1.3660	.93	90000	.03
EBIT	"	112 (0.295)	.1300	.93	8400	.01
CF	"	454 (0.005)	.0789	.87	5484	.03
FF	"	380 (0.060)	.1381	.92	9188	.04
TA	Sales	2312 (0.060)	.6831	.93	63798	.04
CA	"	3491	.3889	.93	38495	.09
QA	"	1703	.1984	.92	19557	.09
TCE	"	140 (0.460)	.5057	.89	45655	.00
NCE	"	995 (0.200)	.4336	.90	39972	.02
EBIT	"	420 (0.070)	.0887	.87	8403	.05
CF	"	622	.0540	.82	5484	.11
FF	"	527 (0.030)	.0962	.89	9188	.06
CA	NCE	4527	.8498	.93	38495	.12
QA	"	2336	.4308	.91	19557	.12
S	"	6813	2.0812	.90	90000	.08
EBIT	"	314 (0.050)	.2024	.94	8403	.04
CF	"	581	.1227	.89	5484	.10
FF	"	618	.2144	.92	9188	.07
CA	TCE	5777	.7166	.90	38495	.15
QA	"	2943	.3639	.89	19557	.15
S	"	9326	1.7671	.89	90000	.10
EBIT	"	583	.1713	.92	8403	.07
CF	"	767	.1033	.86	5484	.14
FF	"	927	.1810	.90	9188	.10

Note: a = regression intercept; b = regression coefficient; R² = Coefficient of Determination. Figures in brackets are levels of significance based on a Student's t test. All other estimates are significant at .000 level. a and M are in £'000

Table 5.2. Regression of Numerator Variables on Deflators

- 5.5. 4 Results of Test of Spurious Correlation: We can now interpret the results of our correlation analysis in the light of the above findings concerning the relationship between the numerators and deflators. These results are presented in Tables 5.3. to 5.6. each table representing the results for one of the four deflators. Alpha is the level of statistical significance and "% change" refers to the difference in percentage terms of the ratio correlation measure from the relative partial correlation. While this percentage is a measure of the difference between partial and ratio correlation and, therefore, of the bias in the two estimates it is not a statistical measure. In other words a large percentage difference need not be statistically significant and vice versa. This can be seen by comparing alpha and % change for some ratio pairs in Tables 5.3. to 5.6.
- 5.5. 5 On the other hand, alpha does not by itself indicate the extent of bias in the two estimates. Again because of the large sample size involved even a small difference between the two estimates is likely to be statistically significant (e.g. the difference between the two estimates in the case of ratio pair TCE/S and NCE/S is just 1% but it is still statistically significant - see Table 5.3). In general, given the large sample size even a small percentage change is likely to be significant at high correlation levels while at lower levels only large percentage changes are likely to be significant. With this caveat we may use both alpha and % change as measures of bias.
- 5.5. 6 Looking at the tables we see that ratio correlation is preponderantly lower than the corresponding partial correlation. Those cases in which it is higher are marked by asterisks. Among these all except the following pairs of ratios have differences between ratio and partial correlation estimates which are either not significant at 0.01 level or, if they are, not exceeding 5%:
- | | |
|---------------------|-------------------|
| TA/S and CA/S | TL/TA and CF/TA |
| QA/S and EBIT/S | TL/TA and FF/TA |
| QA/S and FF/S | TL/TA and EBIT/TA |
| CA/S and TCE/S | QA/TA and EBIT/TA |
| CA/NCE and S/NCE | |
| S/NCE and CF/NCE | |
| EBIT/NCE and FF/NCE | |

1	2	3	4	5	6	7	8	9	10	11	12	13
x/z	y/z	r _{xz}	r _{yz}	r _{xy}	r _{$\frac{x \cdot y}{z \cdot z}$}	r _{xy.z}	r _{$\frac{x}{z} \cdot \frac{y}{z}$}	alpha	% change	V _z	r _{xz} V _x	r _{xy} V _y
TA/S	CA/S	.97	.97	.98	.75	.67	*	.76	.000	13	1.93	1.76
	QA/S		.96	.97	.58	.64		.58	.022	-9		1.76
	TCE/S ⁺		.95	.99	.94	.90	*	.94	.000	4		1.92
	NCE/S ⁺		.95	.99	.91	.90	*	.91	.390	1		1.88
	EBIT/S		.93	.96	.50	.69		.50	.000	-28		1.83
	CF/S		.91	.93	.45	.55		.45	.003	-18		1.71
	FF/S		.94	.95	.46	.52		.46	.034	-12		1.82
CA/S	QA/S	.97	.96	.99	.69	.81		.69	.000	-15	1.76	1.76
	TCE/S		.95	.95	.63	.46	*	.64	.000	37		1.92
	NCE/S		.95	.96	.60	.55	*	.61	.045	9		1.88
	EBIT/S		.93	.95	.44	.52		.45	.006	-15		1.83
	CF/S		.91	.93	.33	.46		.33	.000	-28		1.71
	FF/S		.94	.95	.41	.48		.42	.030	-15		1.82
QA/S	TCE/S	.96	.95	.94	.44	.39	*	.44	.060	13	1.76	1.92
	NCE/S		.95	.95	.49	.46	*	.49	.170	7		1.88
	EBIT/S		.93	.94	.55	.46	*	.56	.001	24		1.83
	CF/S		.91	.92	.38	.41		.38	.264	-7		1.71
	FF/S		.94	.94	.48	.36	*	.48	.000	33		1.82
TCE/S	NCE/S ⁺	.95	.95	1.00	.95	.96		.95	.000	-1	1.92	1.88
	EBIT/S		.93	.96	.45	.68		.45	.000	-34		1.83
	CF/S		.91	.93	.43	.51		.43	.013	-16		1.71
	FF/S		.94	.95	.42	.52		.42	.001	-20		1.82
NCE/S	EBIT/S	.95	.93	.97	.57	.74		.57	.000	-23	1.88	1.83
	CF/S		.91	.94	.55	.59		.55	.108	-7		1.71
	FF/S		.94	.96	.53	.59		.53	.018	-10		1.82
EBIT/S	CF/S	.93	.91	.98	.84	.87		.84	.000	-4	1.83	1.71
	FF/S		.94	.99	.92	.92		.92	1.000	0		1.82
CF/S	FF/S	.91	.94	.98	.84	.92		.84	.000	-9		1.82

See notes to Table 5.6 for key to the symbols and abbreviations

Table 5.3: Ratio Correlation Analysis (Deflator: Sales)

1 x/z	2 y/z	3 r_{xz}	4 r_{yz}	5 r_{xy}	6 $r_{\frac{x,y}{z,z}}$	7 $r_{xy.z}$	8 $r_{\frac{x}{z} \frac{y}{z} .z}$	9 alpha	10 %change	11 V_z	12 $r_{xz} V_x$	13 $r_{yz} V_y$
TL/TA	CA/TA	.98	.98	.97	.15	.29	.19	.000	-48	1.93	1.98	1.77
	QA/TA		.97	.97	.13	.41	.15	.000	-68			1.78
	S/TA		.97	.97	.27	.47	.29	.000	-43			1.87
	EBIT/TA		.96	.94	-.30	-.18 *	-.31	.001	-67			1.89
	CF/TA		.93	.91	-.34	-.17 *	-.34	.000	-100			1.76
	FF/TA		.95	.93	-.24	-.07 *	-.25	.000	-242			1.83
CA/TA	QA/TA	.97	.97	.99	.48	.71	.47	.000	-32		1.77	1.78
	S/TA		.97	.97	.22	.38	.20	.000	-42			1.87
	EBIT/TA		.96	.95	.07	.10	.08	.232	-30			1.89
	CF/TA		.93	.93	-.03	.16	-.04	.001	-119			1.76
	FF/TA		.95	.95	.05	.27	.05	.000	-81			1.83
QA/TA	S/TA	.97	.97	.96	.21	.35	.20	.000	-40		1.78	1.87
	EBIT/TA		.96	.94	.26	.03 *	.26	.000	767			1.89
	CF/TA		.93	.92	.07	.09	.06	.250	-22			1.76
	FF/TA		.95	.94	.19	.13 *	.19	.050	46			1.83
S/TA	EBIT/TA +	.97	.96	.93	.01	-.01	.02	.472	-		1.87	1.89
	CF/TA		.93	.91	.11	.03 *	.11	.021	267			1.76
	FF/TA		.95	.94	.11	.24	.11	.001	-54			1.83
EBIT/TA	CF/TA	.96	.93	.98	.76	.82	.76	.000	-7		1.89	1.76
	FF/TA		.95	.99	.91	.87 *	.76	.000	5			1.83
CF/TA	FF/TA	.93	.95	.98	.82	.86	.82	.000	-5		1.76	1.83

Note: See notes to Table 5.6 for key to abbreviations and symbols.

Table 5.4: Ratio Correlation Analysis (Deflator: Total Assets, TA)

1 x/z	2 y/z	3 r_{xz}	4 r_{yz}	5 r_{xy}	6 $r_{\frac{x}{z} \cdot \frac{y}{z}}$	7 $r_{xy \cdot z}$	8 $r_{\frac{x}{z} \cdot \frac{y}{z} \cdot z}$	9 alpha	10 %change	11 V_z	12 $r_{xz} V_x$	13 $r_{yz} V_y$
CA/NCE	QA/NCE	.96	.95	.97	.78	.84	.77	.000	- 7	1.98	1.75	1.74
	S/NCE		.95	.97	.68	.60 *	.67	.000	13			1.83
	EBIT/NCE		.97	.95	.22	.24	.23	.340	- 8			1.91
	CF/NCE		.94	.93	.15	.24	.14	.013	-375			1.77
	FF/NCE		.96	.95	.27	.38	.26	.001	-29			1.85
QA/NCE	S/NCE	.95	.95	.96	.63	.60 *	.62	.138	5		1.74	1.83
	EBIT/NCE		.97	.94	.32	.25 *	.32	.026	28			1.91
	CF/NCE		.94	.92	.18	.23	.17	.079	-22			1.77
	FF/NCE		.96	.94	.32	.31 *	.32	.378	3			1.85
S/NCE	EBIT/NCE	.95	.97	.93	.21	.14 *	.21	.046	50		1.83	1.91
	CF/NCE		.94	.91	.24	.14 *	.23	.006	71			1.77
	FF/NCE		.96	.94	.30	.36	.30	.064	-17			1.85
EBIT/NCE	CF/NCE	.97	.94	.98	.75	.81	.75	.000	- 7		1.91	1.77
	FF/NCE		.96	.99	.92	.86 *	.92	.000	7			1.85
CF/NCE	FF/NCE	.94	.96	.98	.81	.85	.81	.000	- 6		1.77	1.85

See notes to Table 5.6. for key to symbols and abbreviations.

Table 5.5: Ratio Correlation Analysis (Deflator: Net Capital Employed, NCE)

1	2	3	4	5	6	7	8	9	10	11	12	13
x/z	y/z	r_{xz}	r_{yz}	r_{xy}	$r_{\frac{x}{z}, \frac{y}{z}}$	$r_{xy.z}$	$r_{\frac{x}{z}, \frac{y}{z}.z}$	alpha	%change	V_z	$r_{xz} V_x$	$r_{yz} V_y$
CA/TCE	QA/TCE	.95	.94	.99	.76	.87	.75	.000	-13	2.02	1.73	1.73
	S/TCE		.95	.97	.59	.65	.58	.005	-9			1.82
	EBIT/TCE		.96	.95	.32	.39	.33	.025	-18			1.89
	CF/TCE		.93	.93	.23	.38	.22	.000	-39			1.75
	FF/TCE		.95	.95	.33	.50	.33	.000	-34			1.83
QA/TCE	S/TCE	.94	.95	.96	.55	.64	.54	.000	-14		1.73	1.82
	EBIT/TCE		.96	.94	.42	.37 *	.42	.100	14			1.89
	GF/TCE		.93	.92	.26	.35	.25	.007	-26			1.75
	FF/TCE		.95	.94	.39	.42	.39	.192	-7			1.83
S/TCE	EBIT/TCE	.95	.96	.93	.25	.24 *	.25	.420	4		1.82	1.89
	CF/TCE		.93	.91	.29	.24 *	.29	.120	21			1.75
	FF/TCE		.95	.94	.33	.44	.32	.000	-25			1.83
EBIT/TCE	CF/TCE	.96	.93	.98	.78	.85	.78	.000	-8		1.89	1.75
	FF/TCE		.95	.99	.93	.89 *	.93	.000	4			1.83
CF/TCE	FF/TCE	.93	.95	.98	.83	.88	.83	.000	-5		1.75	1.83

- Note: 1) Alpha is level of significance of difference between ratio and partial correlation and is calculated using Fisher's formula (see Yeomans, p. 212).
 2) V_x , V_y and V_z are the coefficients of variation (see Appendix 5.6).
 3) The symbols + and * are explained in Paragraphs 5.5.6 and 5.5.7.

Table 5.6: Ratio Correlation Analysis (Deflator: Total Capital Employed, TCE)

5.5. 7 The tables also indicate that the homogeneity condition, $V_z = r_{xz} V_x = r_{yz} V_y$ (see Appendix 5.6) is satisfied only in the case of the following ratio pairs (marked + in Tables 5.3 to 5.6).

TA/S and TCE/S

TA/S and NCE/S

TCE/S and NCE/S

S/TA and EBIT/TA

This is shown by the near equality of the last three columns of the tables. For the second and fourth of these ratio pairs the differences between ratio and partial correlations is highly non-significant while in the case of the other two it is significant but in percentage terms less than 4%. This result is in accord with KM's theoretical reasoning. Reference to Table 5.2 shows that the numerators of the above four pairs of ratios are highly homogeneous with regard to their respective deflators.

5.5. 8 However, there are other pairs of numerator variables which, although they are homogeneous with respect to deflators, do yield significantly different estimates of partial and ratio correlations contrary to KM's formulation. Where, however, one of the numerators is homogeneous and the other is not the difference appears to be much less than when both are non-homogeneous. This is seen from the fact that in almost every case of non-significant or small percentage bias one of the numerators is homogeneously related to the deflator.

5.5. 9 On the whole, so far as the homogeneity condition is concerned, there is no clear pattern to the bias in ratio correlation compared to partial correlation. It would appear that the homogeneity condition alone is inadequate to explain the results. Another important feature of the results is that ratio correlation tends to be lower than partial correlation. It is not clear whether this tendency arises from the process of deflation or from a possible upward bias in the partial correlation estimate. The likely sources of bias in the two correlation estimates are investigated in Appendix 5.6 and briefly summarised below.

5.5.10 We have shown that

- 1) in the presence of heteroscedastic error partial correlation estimates will be highly exaggerated whereas deflation tends to stabilise the error variance. The ratio correlation will, therefore, be less than the corresponding partial correlation
- 2) the effect of non-zero intercepts (i.e. a non-homogeneous relationship between the numerator and the deflator) leads, as pointed out by KM, to the ratio correlation being a biased estimate of the partial correlation and
- 3) that in assessing the usefulness of deflation in estimating the true residual correlation both the above factors have to be taken into account.

5.5.11 We may now explain the general pattern of our results in which the ratio correlation tends to be lower than the partial correlation. In Appendix 5.7 are shown the scattergrams of various numerator variables with respect to their deflators. These exhibit a general tendency towards heteroscedasticity. There is, however, no strong indication of non-linearity. Such heteroscedastic error variances are in accord with a priori expectations since larger firms are likely to vary more widely in terms of their financial profile on such measures as gearing, inventory level, debtors, fixed assets etc. As noted by KM (p.406),

"with undeflated cross-section data the assumption of constant error variance usually is not appropriate. Just as small firms have small observations, they may have small shocks, while the opposite is true for larger firms".

5.5.12 Our results are in striking agreement with those obtained by Brown, Greenwood and Wood (1914, hereafter, BGW) who compared the partial correlation $r_{xy.z}$ with both the ratio correlation $\frac{r_{x.y}}{z}$ and the partial ratio correlation $\frac{r_{x.y}}{z} \cdot \frac{r_{y.z}}{z}$ all of which have been calculated for our data (See Tables 5.3 to 5.6). We find from these tables that there is very little difference between the last two correlations, a result similar to that of BGW, suggesting that on deflation the effect of the size deflator may have been completely eliminated. Summarising their findings BGW remark

"in some cases the differences (between $r_{xy.z}$ and $r_{\frac{x}{z} \frac{y}{z} .z}$) are large although not necessarily significant and in most cases $r_{xy.z}$ is larger than $r_{\frac{x}{z} \frac{y}{z} .z}$. Another point to be noted is the fact that $r_{\frac{x}{z} \frac{y}{z} .z}$ rarely differs significantly from $r_{\frac{x}{z} \frac{y}{z}}$ " (p. 319).

They suggest that in practice ratio correlation could be used in the place of partial correlation.

5.5.13 Discussing the causes of discrepancy between partial correlation and partial ratio correlation BGW say that

"these differences are in part due to the fact that in calculating $r_{xy.z}$ each observation is weighted by its actual size"

whereas on deflation

"no single observation can have any predominating effect in determining the slope of the regression surface" (p. 320).

This reasoning is the same as the one we have put forward in discussing the effect of heteroscedasticity (see Appendix 5.6 and also KM, p. 407). In the next section we summarise our test results and discuss their implications.

5.6. Summary and Implications of the Test Results for Financial Analysis

5.6.1 Our results show

- 1) that the influence of size on both the balance sheet (BS) and income statement (IS) variables is considerable and justify the traditional concern in financial analysis with the elimination of the size effect in both inter-company and intra-company comparisons.
- 2) that linearity is a reasonable approximation of the relationship between the financial variables and the size measures as indicated by both the high coefficients of determination in Table 5.2 and

the scattergrams in Appendix 5.7. In this regard BS variables are not systematically different from the IS variables although there is some evidence in the literature that some variables like inventory may be non-linearly related to size³. It is plausible that such non-linearity may exist in time-series rather than cross-section data

- 3) that balance sheet variables like current assets, quick assets etc. tend to be less homogeneous than IS variables with respect to size (see the regression intercepts in Table 5.2) and
- 4) that the financial variables investigated are, in general, heteroscedastic with respect to the four size measures.

5.6. 2 Spurious Correlation Test Results: These results show

- 1) that ratio correlation is in general lower than the corresponding partial correlation. Given the heteroscedasticity noted above the partial correlation estimates, as argued in Appendix 5.6, would appear to be inflated. Ratio correlation, by minimising the effect of heteroscedasticity, appears to be closer to the true residual correlation
- 2) that the two estimates diverge widely when one or both of the numerator variables is a BS variable and more so when one of them is a BS variable and the other an IS variable (see Tables 5.3 to 5.6 where the divergence is indicated by "alpha" and "% change"). This is consistent with the result noted in the previous paragraph that BS variables tend to be less homogeneous than IS variables. Because of the tendency of the BS variables to be non-homogeneous with respect to size partial correlation is in general more appropriate than ratio correlation as a measure of the true residual correlation provided that the condition of homoscedasticity is satisfied
- 3) that fear of spuriously high ratio correlations resulting from the use of common deflators is largely misplaced. On the contrary ratio transformation has been shown to have beneficial consequences for the estimation of the true residual correlation among variables and

3. This is the well known square-root formula for economic order quantity (EOQ) of inventory in which EOQ is a function of $\sqrt{D}$ where D is the expected demand per year (For a discussion of this model see Samuels and Wilkes, 1980).

4) that where both the sources of discrepancy between ratio and partial correlations are present (see Appendix 5.6) the appropriateness of ratio transformation would depend upon the relative strengths of deviations from the conditions of homogeneity and homoscedasticity

5.6. 3 Choice of Size Measure for Deflation: The four size measures Sales, Total Assets, Total Capital Employed (TCE) and Net Capital Employed (NCE) are very highly correlated (R^2 exceeds 0.89 as seen in Table 5.2). Shalit and Sankar (1977) who have investigated the conditions for interchangeability among different measures of size conclude that "there is no single satisfactory solution to the theoretical issues" involved (p.293) but indicate that in practice size measures which are highly correlated may be regarded as inter-changeable (p. 297). Smyth et al (1975) have, however, argued that alternative size measures under deterministic conditions are not inter-changeable unless they are proportional (p.111).

5.6. 4 We have argued that a good deflator must satisfy the homogeneity as well as homoscedasticity conditions in order that deflation results in an unbiased estimate of the marginal effect of size on the variable examined and leads to an unbiased estimate of the true residual correlation whenever ratio correlation is used as a short-cut to estimating the association between two variables after allowing for the size effect. It would appear that the choice of a deflator from among alternative size measures would depend on the extent to which each of them satisfies the two conditions referred to above. From our results Total Assets and Sales appear to be more appropriate as deflators than TCE and NCE at least in cross-section studies.

5.7. Statistical Distribution of Ratios and Their Transformation

5.7. 1 The assumption of multivariate normality forms the basis of much of the standard multivariate statistical methodology including the factor and discriminant analytic models employed in this research. "The effects of departures from normality on the methods are not easily or clearly understood" (Gnanadesikan, 1977, p. 161) although, it may be argued that, strictly speaking, no valid statistical inferences from or about

the data suffering from serious non-normality may be drawn. An analysis of the statistical distribution of the ratios used in this research is, therefore, essential in order to examine the conformance of our data to the underlying assumptions of our models and the extent, if any, of non-conformance so that the limitations of the models may be fully appreciated.

- 5.7. 2 Multivariate normality implies the joint normality of all the variables constituting the multivariate set as well as the joint normality of every subset of those variables. The latter condition means marginal normality of each of the variables in the set which is a necessary but not a sufficient condition for multivariate normality. While multivariate normality may be established by a single test of joint normality of the variables

"in practice a single overall multivariate analysis of data is seldom sufficient or adequate by itself and almost always it needs to be augmented by analyses of subsets of the responses (variables), including univariate analyses of each of the original variables. Although marginal normality does not imply joint normality, the presence of many types of non-normality is often reflected in the marginal distributions as well"
(Gnanadesikan , p. 163)

- 5.7. 3 In order to assess the distributional characteristics of multivariate data, it is necessary to test for both marginal, univariate normality and joint normality. Tests for univariate normality are now fairly well established in the literature. However, tests of multivariate normality are still in a state of evolution. While several techniques have been proposed (see Gnanadesikan 1977, for a summary) these have not yet become available to the applied researcher in a readily usable form. Moreover, examination of the univariate distributions is likely to provide general indication of the adherence to multivariate normality by our data.

- 5.7. 4 Univariate Distribution of Financial Ratios: Univariate normality of the ratios was assessed using three statistics. For each ratio the Chi Square statistic of fit to the normal distribution, skewness and

kurtosis were calculated ⁴. While the Chi Square statistic was used as an overall measure of the degree of fit of the actual distribution to the normal, the higher moments were used to provide an additional feel for the data. In addition as the Chi Square test is sensitive to extreme values of observations, the additional statistics were used to provide a check on its waywardness. For a normal distribution skewness and kurtosis must have values zero and three respectively and their actual values indicate the extent and nature of any deviation from the normal distribution. Thus all the three statistics were used to evaluate the normality of the ratio distributions.

5.7. 5 Appendix 5.8 presents the Chi Square, skewness and kurtosis statistics for the untransformed ratios as well as for four different transformations of those ratios. The statistics were calculated for both the manufacturing and distribution samples for each of the 6 years studied. In computing the statistics extreme outliers defined as those observations beyond 3.5 standard deviations from the mean were excluded and the mean and standard deviation were re-calculated. This was done in order to minimise the disproportionate effect that extreme outliers have on the distribution of a variable. Based on this new mean and standard deviation the data were "Winsorized" by resetting all outliers to 3 standard deviations from the mean (see Lev. & Sunder (1979) on Winsorizing and other manipulation of data to bring about greater normality). The effect of Winsorizing on the calculated Chi Square, skewness and kurtosis is likely to be minimal since the re-set outliers are still quite far removed from the mean. The Chi Square values are, however, likely to be understated as a result of Winsorizing. The effect of Winsorizing is to "bound" the distributions and bounded distributions are held to mitigate the consequences of non-normality in employing multiple discriminant analysis ⁵.

5.7. 6 The data were divided into 14 class intervals yielding 11 degrees of freedom, allowing 3 degrees of freedom for the mean, standard deviation

4. For the formulae used in the computation of these statistics see Nie et al, (1975).

5. See Section 7.4 of Chapter 7 for a further discussion of this point.

and sample size. At the 10% level of significance ($\alpha = .10$) the Chi Square value is 5.578. From the tables in Appendix 5.8 it may be observed that in the case of every ratio the calculated Chi Square exceeds this theoretical value leading to the rejection of the null hypothesis of distribution normality⁶. Indeed the only ratio with at least 50% chance of being drawn from a normal distribution is Total Liabilities/Total Assets which has calculated Chi Square less than the theoretical Chi Square at = 0.50 in 1973-74. Interestingly enough, in his analysis of the distributions of 11 financial ratios for 19 years, Deakin (1976) found the ratio Total Debt/Total assets to be the most normal.

- 5.7. 7 All ratios other than those listed below were positively skewed. The predominance of positively skewed distributions among financial ratios is in conformity with the findings of Horrigan (1965) and O'Connor (1973) and arises from the fact that for most ratios there is a lower limit of zero but no upper limit. There is thus an inbuilt asymmetry in the distributions of these ratios.

Ratios which are not Significantly Positively Skewed⁷

WC/TNW

WC/NCE

CA/TA

Days Debtors

DR/CA

INV/CA

- 5.7. 8 The ratios also showed a pre-dominantly leptokurtic or high peaked distribution indicated by the kurtosis values exceeding three in the tables. The only ratios with values consistently lower than three are

TL/TA

Debt/TCE

Debt/TA

AQA/PDOE

VA/ER

6. Similar results were obtained by Bougen and Drury (1980) in their analysis of seven financial ratios.

7. Ratios AQA/PDOE, TNI/ATA, NI/ANW, TNI/ATNW and TL/TA, were also not positively skewed in some though not all six years.

A leptokurtic curve is high with long tails while a platykurtic one is squat with short tails. A combined reading of the skewness and kurtosis of the ratio distributions would appear to indicate a close clustering of most firms around their mean while a few firms are quite far away from the mean.

5.7. 9 Transformation of Ratios to Normality: Several data-based transformations have been proposed in the literature to bring about greater normality (see Gnanadesikan 1977, p. 137-150) so that the assumptions of the multivariate normal models can be met. Both logarithmic and square root transformations have been suggested to correct positively skewed distributions (see Horrigan (1965) and also Rummel, 1970). Deakin (1976) reports the results of these transformations which he applied to 11 financial ratios and concludes that "there appear to be cases in which both the square roots of the data and the natural logs of data were normally distributed" (p. 96). Rummel (1970) also recommends other transformations such as the reciprocal. In our study we applied the following transformations to the ratios ⁸:

- 1) Natural logarithm
- 2) Reciprocal
- 3) Square root
- 4) Square root of the reciprocal

For each transformation Chi Square, Skewness and Kurtosis were calculated and the results are shown in the tables in Appendix 5.8. It will be seen that in the case of most ratios there is a great deal of improvement although not enough to accept the null hypothesis of no departure from normality.

5.7.10 The "best" transformation for a ratio was decided on the basis of the following rules of thumb:

- 1) the lowest Chi Square value or
- 2) if Chi Square values similar, the least skewed or
- 3) if Chi Square values and skew values similar, the lowest kurtosis value.

8. Since the square root and logarithmic transformations require ratio values to be positive suitable constants were added to make them positive. This amounts to shifting the origin. Although the addition of a constant will affect the distribution of the transformed ratios the effect is considered unlikely to be significant (see Gnanadesikan(1977)on the addition of constants, p. 143).

The importance attached to skewness stems from the fact that symmetry of distribution is a useful property in the application of statistical models requiring normality (see Gnanadesikan, 1977 and Chapter 7, Section 5).

Since outliers were re-set as indicated in Paragraph 5.7. 5, in order to preserve as much of the original distribution of data as possible, consideration was also given to the number of outliers re-set in choosing the "best" transformation.

5.7.11 Analysis of the "best" transformation for each ratio for the 6 years studied showed that while most of the balance sheet ratios had the same "best" transformation in all 6 years some of the ratios involving profit and loss account items showed much greater instability. This result held for both the samples and is plausible since profit and loss account items are more subject to fluctuations and manipulations than the balance sheet items. The final transformations applied to the ratios were selected on the basis of the six-year results. In order to maintain inter-temporal comparability the same transformations were applied for all the 6 years once the best transformation was decided. For reasons of comparability especially in the case of the two group discriminant analysis between the manufacturing and distribution companies, the same transformations were applied to the distribution sample as to the manufacturing sample. The best transformations for the two samples are given in Appendix 5.9. While most of the transformations were identical for the two samples in the case of some ratios they differed. These exceptions are circled in Appendix 5.9. indicating that the best transformations for the distribution sample, were different from those for the manufacturing sample.

5.8. Summary and Conclusions

5.8. 1 In this chapter we described the criteria used in the selection of our samples of firms and the steps taken to standardise the reported accounting numbers to facilitate a meaningful inter-firm comparison. Additionally we examined the theoretical issues involved in the transformation of raw accounting numbers into ratios, specifically the implicit objective of the elimination of the size effect. The condition stated in the literature for a valid transformation is that

the variable being transformed should be a homogeneous function of the deflator. When this condition is violated the ratio is no longer an unbiased estimate of the true marginal effect of size on the variable which is the object of interest to the financial analyst in comparisons of firms of different sizes.

5.8. 2 We also investigated theoretically the problem of spurious ratio correlation which has aroused much concern in the financial literature. Following Kuh and Meyer (1955) we argued that a true measure of spuriousness in the correlation between two ratios having a common deflator is the divergence between the ratio correlation estimate and the corresponding partial correlation estimate with the effect of size held constant. Our analysis showed that the condition for non-spurious ratio correlation is the same as for valid ratio transformation viz. homogeneity. When this condition is violated ratio correlation is no longer an unbiased estimate of the true residual association between the numerator variables after the elimination of the size effect.

5.8. 3 Empirical testing of the homogeneity condition and the extent of spurious ratio correlation using the 1976 manufacturing sample showed

- 1) that balance sheet variables were less amenable than income statement variables to a valid ratio transformation
- 2) that some size measures e.g., Sales and Total Assets were more appropriate as size deflators than others since they satisfy the homogeneity condition better and
- 3) that the problem of spurious ratio correlation might be exaggerated and that in the presence of certain forms of heteroscedasticity ratio correlation may indeed be closer than the corresponding partial correlation to the true residual correlation.

5.8. 4 Our examination of the distributional properties of the 87 ratios in our data set showed that none of the ratios was normally distributed, a result consistent with those reported in the previous studies. In terms of both the number of financial ratios investigated and the number of statistics calculated to assess their distributional

properties the present study is more comprehensive than all the previous studies. Since normality is a necessary condition for the valid application of the MDA four different transformations of the raw ratios were carried out to improve their distributions to greater normality and symmetry. The final transformations applied to the data were the ones which resulted in the greatest improvement.

5.8. 5 The properties of individual ratios formed a major focus of this chapter. In multivariate discriminant models the inter-relationship among the variables is an important consideration from the viewpoints of both statistical and substantive interpretation. This important question is taken up in the next chapter. There we shall examine the inter-correlations among the 87 ratios and the statistical redundancy, if any, among them. The spurious ratio correlation results of this chapter have important implications for the validity of the PCA results.

Chapter 6

The Financial Dimensions of Manufacturing and Distribution Firms

6.0 Introduction

It was noted in the last chapter (see paragraph 5.2.4.) that our variable set was quite large being made up of 87 ratios. The inclusion of such a large number of ratios has been necessitated by the fact that financial analysts and researchers have tended to use a wide variety of measures often claiming special virtues of superior substantive validity or empirical insight for the particular ratios used by them. It was observed by Benishay (1971) that:

"there exists a persistent tendency to compute too many ratios and to present them as if they were, truly and logically, independent units of evidence". (p. 174)

While this proclivity may be regarded by many analysts as an expression of their ingenuity or profound insight it makes the choice of ratios for any particular analysis immensely difficult. Equally daunting is the task of reconciling different studies using different but seemingly related ratios.

6.1 Problem of Redundancy in Financial Ratio Analysis:

- 6.1.1 In statistical ratio analysis redundancy of financial ratios has a different effect. Variables which are correlated are collinear and in regression models collinearity has serious implications for the stability and statistical significance of coefficients (see Koutsoyiannis, 1977). In the context of discriminant analysis which is employed in our study, there are differing opinions as to the consequences of collinearity. Eisenbeis (1977) has argued that it is not a relevant consideration whereas Scott (1978) opines that the relative importance of variables in a discriminant model would be affected by collinearity. Indeed, Altman and Eisenbeis (1978) after ranking the same discriminant variables by different methods note that "if the variables are uncorrelated, there will be strong agreement among the ranking methods discussed". (p. 190).

- 6.1. 2 Another advantage in ensuring the presence of uncorrelated ratios in the discriminant models we derive is the enhanced ease of interpretation. Thus, although as a concession to the prevalent practice of analysts and researchers we have compiled a large set of ratios we have identified the inter-relationships among, or the dimensionality of, these ratios in order to facilitate substantive and statistical interpretation of the discriminant models that we shall present in the next three chapters.
- 6.1. 3 Identification of the basic dimensions of our data was carried out using the statistical technique of Principal Components Analysis (PCA) ¹. The Manufacturing and Distribution Samples were separately analysed for each of the six years 1972 to 1977. The results of the analyses are presented separately and the dimensions of the two samples are then compared. For each sample the stability of the dimensions in terms of their ratio composition is also examined. The number of components (the term being used interchangeably with "dimensions") extracted was determined using Kaiser's rule that the eigen value of the component should equal or exceed 1.0. Solutions with both orthogonal and oblique components were obtained in order to ensure that the orthogonality of the components resulted from naturally uncorrelated clusters, if any, of the original variables and not from any artificial criteria imposed by the process of component extraction.
- 6.1. 4 In the last chapter the problem of "spurious" ratio correlation arising from the transformation of raw accounting numbers into ratios using common size deflators was investigated. The empirical analysis of this problem showed that concern over "spurious" ratio correlation might be exaggerated and that ratio transformation using size

1. A brief outline of PCA is provided in Appendix 6.1. The analyses were carried out using the Statistical Package for the Social Sciences (SPSS), see Nie et al (1975).

deflators might often be beneficial. This result is especially significant in the context of the principal components analysis of our data set since many of the ratios included in it have common deflators (see Appendix 5.4) and since the analysis is based on the inter-correlations of the ratios. This finding also supports the validity of the PCA results presented in this chapter lending greater credibility to the ratio groups derived from the analysis ².

6.2. Financial Dimensions of Manufacturing Firms

6.2. 1 Principal component analysis of the manufacturing sample for each of the six years was carried out. Initially orthogonal components based on the varimax criterion were derived. The number of components extracted was determined by the application of Kaiser's rule. This resulted in twelve components in 1972 and 1976, eleven in 1973, 1975 and 1977 and ten in 1974. The eleventh and twelfth components when extracted accounted for a small amount of residual variance in the ratios not already captured by the first ten components ³. Further, the latter represented well defined ratio clusters and remained fairly stable over time. We, therefore, restrict our analysis to these.

6.2. 2 In Appendix 6.2 are shown the ten varimax - rotated orthogonal components, their ratio composition and the loadings in each of six years 1972-77. These components represent the fundamental financial dimensions of the manufacturing firms in our sample and are listed in Table 6.1. These dimensions were able to capture most of the information in our data since they accounted, on average, for 87% of the total variance. The orthogonal loadings matrix for 1977 which broadly reflects the dimensionality of the manufacturing sample for the six year period is shown in Table 6.2. The 1977 results differ from those of the earlier years in that Trade Creditors does not appear as a strongly independent dimension. This point is further discussed in the following paragraphs.

2. This conclusion based on our analysis of ratios with common denominators is considered applicable to ratios with common numerators of which there are a small number in our data set.

3. The residual variance explained ranged from 1.2% in 1973 to 3.4% in 1976.

Number	Name of Dimension	Short Reference
1	Profitability	PFT
2	Long Term Solvency	LTS
3	Short Term Solvency	STS
4	Short Term Asset Intensity	STAI
5	Structural Liquidity	SL
6	Turnover	TO
7	Labour Intensity	LI
8	Trade Creditors	TCr
9	Size	Size ⁴
10	Dividend Payout	DP

Table 6.1 : Orthogonal Financial Dimensions of Manufacturing Firms

6.2. 3 Temporal Stability of the Financial Dimensions: In terms of the loadings shown in Appendix 6.2 which represent the correlation between the dimensions and the ratios constituting them there is considerable stability over the six year period of our study. In terms of the ratio composition and the consistency of loading the most stable dimensions are:

- 1) Size
- 2) Labour Intensity
- 3) Dividend Payout and
- 4) Profitability

The least stable dimensions are those relating to the sources of finance:

- 1) Long Term Solvency
- 2) Short Term Solvency and
- 3) Trade Creditors

6.2. 4 The LTS and STS dimensions are fairly well-defined orthogonal dimensions in the years 1972-74. During these years the constituent ratios of each dimension have secondary loadings on the other

-
4. The very tight grouping of all the size measures is consistent with the high inter-correlations among them observed in the context of the homogeneity tests presented in Chapter 5 (See Table 5.2).

Ratio	<u>Component</u>										
	1	2	3	4	5	6	7	8	9	10	11
FF/S	.69										
EBIT/S	.76										
PBT/S	.75										
TNI/S	.70										
CF/S	.75										
FF/ATA	.89										
FF/ATCE	.85										
EBIT/ATA	.91										
EBIT/ATCE	.86										
PBT/ATA	.89										
PBT/ATCE	.85										
PBT/ANCE	.85										
PBT/ATNW	.84	Profitability (PFT)									
TNI/ATA	.90										
TNI/ATCE	.91										
TNI/ANCE	.91										
TNI/ATNW	.90										
NI/ANW	.91										
CF/ATA	.84										
CF/ATCE	.89										
CF/ANCE	.87										
OSCF/AOSE	.81										
EBIT/ATL	.71										
PBT/ATL	.75										
TNI/ATL	.76										
CF/ATL	.73										
PBT/ACL	.74										
TNI/ACL	.75										
CF/ACL	.73										

- contd

Ratio	1	2	3	4	5	6	7	8	9	10	11
CA/CL		.78									
CA/TL		.67									
WC/TL		.80									
WC/DR		.61									
TNW/TA ³		.94									
(QA-CL)/PDOE		.57									
QA/CL ^S		.57			.65						
QA/TL		.55									
CL/TNW		-.95									
TL/TNW		-.93									
TL/TA		-.93									
CL/TA		-.90									
WC/INV		.58									
AWC/S ^S		.54	.61								
ACr/COS			.58								
ATNW/S			.74								
ACA/S			.88								
AQA/S			.78								
AQA/PDOE			.76								
DAYSDRS			.73								
S/ATA			-.92								
S/ATCE			-.77								
S/ANCE			-.74								
FA/TA				-.92							
CA/TA				.93							
WC/TNW				.90							
WC/NCE				.89							
S/AFA				.72							
CA/TNW ^S		-.76		.58							
DR/CA					.69						
DR/INV					.86						
QA/TA					.80						
INV/CL					-.56						
QA/TNW ^S		-.68			.61						
INV/CA					-.90						
AINV/COS ³					-.61						
AINV/S ³					-.64						

Short Term
Solvency (STS)

Turnover (TO)

Short Term Asset
Intensity (STAI)

Structural
Liquidity (SL)

- contd

Ratio	1	2	3	4	5	6	7	8	9	10	11
TOT.ASS						.95					
TNW						.96					
TCE						.95	Size				
NCE						.94					
SALES						.95					
DEBT/TNW						-.69					
DEBT/TCE						-.69					
DEBT/TA						-.78	Long Term				
DEBT/CA						-.71	Solvency (LTS)				
DEBT/QA						-.71					
Dr/Cr ^S		.48				-.37					
Cr/CL ³						.67					
VA/S								.66			
VA/ATA								.84			
VA/ATCE								.79	Labour		
VA/ANCE								.77	Intensity (LI)		
ER/VA ³								.65			
ER/TA ³								.85			
DIV/OSE1								.62	Dividend		
DIV/OSNI								.82	Payout (DP)		
INT/EBIT								.54	.60		
% Variance											
Explained	30.2	16.2	11.0	7.7	7.6	5.5	3.2	2.9	2.1	1.5	1.2
Cumulative											
% Variance Explained	30.2	46.4	57.4	65.1	72.8	78.2	81.4	84.3	86.4	87.9	89.1

- Note: 1) S indicates a ratio classified on the basis of its secondary loading to permit comparison with the oblique rotation results and overtime.
- 2) Secondary loadings are not shown except as noted in the last note. Primary loadings on component 11 were $< .30$ and hence not shown.
- 3) Reciprocal transformed ratios. See Appendix 5.9 for the transformations applied to the other ratios.
- 4) All the loadings are statistically significant (see Appendix 6.2 for test of significance using the Burt-Bank's formula)

Table 6.2: Varimax-rotated Principal Components Loadings Matrix -
1977 Manufacturing Sample

dimension but these are generally small. In 1975 and 1976, however, the two dimensions appear to merge into a single solvency dimension. However, the two dimensions are once again distinct in 1977 but the ratio composition has now undergone a discernible change. Trade Creditors has maintained its distinct orthogonality in all years but 1977 when it merges into Long Term Solvency.

6.2. 5 The remaining three dimensions, Turnover, Structural Liquidity and Short Term Asset Intensity are fairly stable over time in terms of their ratio composition but the component loadings show some variation from year to year in the case of a few ratios. The variations in the composition of these and the least stable dimensions noted above are probably due to sample variation and measurement errors⁵. They could also be due to non-random changes in the substantive relationship among the ratios constituting these dimensions over time.

6.2. 6 The above ratio dimensions were extracted subject to the orthogonality condition. As noted in the last section, mere orthogonal rotation will not reveal whether the lack of correlation among the resulting dimensions is empirical or imposed by the factor model. By removing the rigidity imposed by the orthogonality condition oblique rotation could possibly identify the underlying natural ratio clusters more clearly. Since orthogonal rotation is a subset of oblique rotation, if the ratio clusters are indeed uncorrelated then oblique rotation will result in orthogonal factors (Rummel 1970, p. 386). Accordingly, oblique components using the direct oblimin criterion were derived⁶.

5. In Section 5.2, Chapter 5, reference was made to the imperfections of accounting data. Because of the imprecision in the valuation concepts in accounting, the wide diversity of accounting methods in practice and the subjectivity involved in the valuation process accounting data are quite likely to have measurement errors. The variations in the activities of firms over time means that the same firms may constitute slightly different samples from one period to another. Also, the 1977 sample is smaller than those of the other years (see Section 5.1).

6. For a description of the oblique rotation technique and the direct oblimin criterion see Appendix 6.1.

6.2. 7 Financial Dimensions by Oblique Rotation: Appendix 6.3 provides the oblique pattern loadings for 1972-77 ⁷. The most notable changes have occurred in Profitability, now split into two dimensions - Pre-tax Return on Assets (ROA) and Post-tax Return on Assets - and in the solvency dimensions, LTS and STS. These two dimensions are much more distinct and stable than under orthogonal rotation. Similarly, Trade Creditors also remains a very distinct dimension even in 1977 whereas under the orthogonal rotation it had merged with LTS. There is no appreciable change in the composition or strength of loading of the other dimensions. The important pairwise correlations among the oblique components are shown in Table 6.3.

Between Oblique Components	Correlation Coefficient
Pre-tax and Post-tax ROA	.71
LTS and STS	.41
Size and LI	.34
STS and TCr	.24
LTS and TCr	.23

- Note: 1) The correlation coefficients have been averaged over six years. The other components were correlated at less than .20 indicating that their pairwise common variance was less than 4%. This is considered too small to justify further analysis.
- 2) The correlation coefficient between Pre-tax and Post-tax ROA was taken as 1 in 1974 and 1977 when the two components coincided.

Table 6.3: Average Component Pattern Correlation Coefficients

6.2. 8 The very high correlation between Pre-tax and Post-tax ROA explains the reason why they combined to form a single Profitability dimension in the orthogonal solution. It is also clear that LTS, STS and TCr are not strictly orthogonal but correlated. The pairwise correlation is strongest in the case of LTS and STS. The relationship among the

7. See Appendix 6.1 for an explanation of oblique pattern loadings.

different oblique dimensions is brought out much more elegantly when the results of a second-order PCA performed on the first order pattern correlation matrix are considered.

6.2. 9 Second order (or secondary) components are derived by subjecting the matrix of correlations among the first order (or primary) components to PCA (See Child, 1976). The secondary components are each a cluster of the primaries which are most highly inter-related. The loadings of the primaries on the secondaries are interpreted in the same way as in the first order solution and indicate the strength of association between the primary and secondary components. The results of a second order PCA on the primary correlation matrix for 1975 are presented in Table 6.4. The composition of the secondary components can provide considerable insight into the structure of the data analysed. The secondaries, the primaries and the observed ratios may be regarded as representing three different levels of integration of firms' financial characteristics. Figure 6.1 illustrates this interpretation of the results provided in Table 6.4.

First Order Oblique Components	Loadings on Second Order Orthogonal Components				
	1	2	3	4	5
1. Pre-tax Return on Assets	.85				
2. Post-tax Return on Assets	.82				
3. Dividend Payout	.56				
4. Long Term Solvency		.77			
5. Short Term Solvency		.82			
6. Trade Creditors		-.47			
7. Size			.73		
8. Labour Intensity			-.78		
9. Turnover			-.53		
10. Structural Liquidity				.87	
11. Short Term Asset Intensity					.88
% variance explained by component	18.6	15.4	12.5	10.4	9.1
cumulative % variance explained	18.6	33.9	46.5	56.9	66.0

Note: These results relate to 1975. The results for the other years were broadly similar and hence not presented.

Table 6.4: Second Order Principal Components of Manufacturing Firms

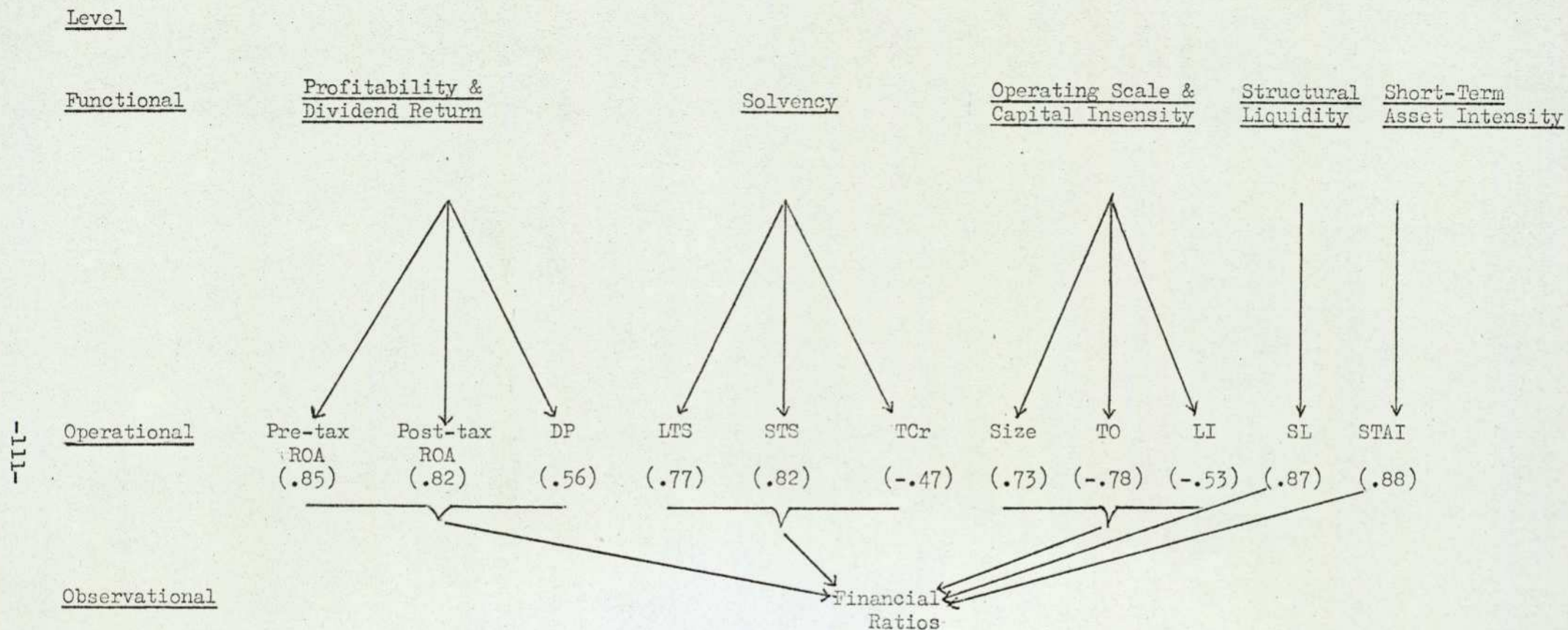


Figure 6.1: Hierarchical Financial Dimensions of Manufacturing Firms in 1975

Note: 1) Figures in parentheses are the loadings of operational level components on functional level components reproduced from Table 6.4.

2) For key to abbreviations see Appendix 6.3.

6.2. 10 The above analysis demonstrates the ability of oblique rotation to identify the true ratio clusters in the data which the rigidities of orthogonality appear to have obscured to some degree. However, the oblique solutions broadly confirm that the dimensions we have identified are essentially orthogonal. Moreover, the ratio clusters may be regarded as fairly stable after allowing for sample variations, measurement errors and the dimensions in sample size in 1977.

6.3 Financial Dimensions of Distribution Firms

6.3. 1 PCA on broadly similar lines was repeated with our sample of distribution firms. Distribution firms have different operating characteristics from manufacturing firms in terms of employment of capital and manpower resources, levels of inventory, terms of credit etc. These differences may also be expected to be reflected in the financial strategies pursued by firms in either sector and in the resulting financing mix. While in the next chapter we shall investigate which particular aspects of distribution firms set them apart from manufacturing firms, in this section we shall examine the differences in the overall financial dimensions between the two sectors.

6.3. 2 PCA of the distribution sample was carried out for each of the six years. The annual results were generally consistent as regards nine major dimensions although the number of components extracted by Kaiser's rule exceeded nine. The minor components merely captured the residual variance not already accounted for by the major dimensions⁸. The nine dimensions listed in Table 6.5 accounted, on average, for 87.1% of the total variance in the data⁹. Thus, as with the manufacturing sample, dimensionality reduction was accomplished without much information loss. The orthogonal loadings matrix for 1977 which broadly reflects the dimensionality of accounting data for the distribution sample over the six year period is shown in Table 6.6.

8. The number of components derived was 11 (1972), 10 (1973) 11 (1974), 12 (1975), 11 (1976) and 12 (1977). On average the omitted components explained less than 4% of the variance in the data.

9. The average was calculated from the cumulative variance of the nine components shown in Appendix 6.4.

No.	Dimension	Short Reference
1.	Profitability	PFT
2.	Short Term Solvency	STS
3.	Short Term Asset Intensity	STAI
4.	Turnover	TO
5.	Structural Liquidity	SL
6.	Long Term Solvency	LTS
7.	Size ¹⁰	SIZE
8.	Labour Intensity	LI
9.	Dividend Payout	DP

Table 6.5: Financial Dimensions of Distribution Firms

6.3. 3 The above financial dimensions remained fairly stable across the time period, as evidenced by a comparison of the orthogonal component loadings for the six years presented in Appendix 6.4¹¹.

The loadings of ratios and the composition of the dimensions indicate that the financial dimensions of distribution firms are fairly stable over time. The variations in the loadings of some of the ratios like the profit margin ratios are probably random or due to measurement errors arising from the accounting treatment of various items¹².

Thus, we may conclude that a ratio representing a given dimension of the distribution firms in 1972 continued to be representative of the same dimension in 1977.

6.4 Comparison of the Financial Dimensions of Manufacturing and Distribution Firms

6.4. 1 On comparing the dimensions of the two samples (see Tables 6.2 and 6.6 and Appendices 6.2 and 6.4) we find that the major dimensions are the same with one exception, Trade Creditors. In the case of the manufacturing sample it was a distinct dimension in all years except

10. The close clustering of the size measures once again confirms the results presented in Chapter 3; see footnote 4 to this chapter.

11. Oblique rotation was also carried out but the results are not presented since they did not differ materially from those of the orthogonal solution.

12. See footnote 5 to this chapter.

Ratio	<u>Component</u>									
	1	2	3	4	5	6	7	8	9	10
FF/ATA	.67									
FF/ATCE	.66									
EBIT/ATA	.67									
EBIT/ATCE	.72									
PBT/ATA	.64									
PBT/ATCE	.69									
PBT/ANCE	.66									
PBT/ATNW	.67									
TNI/ATA	.84									
TNI/ATCE	.75									
TNI/ANCE	.79									
TNI/ATNW	.83									
NI/ANW	.83									
CF/ATA	.93									
CF/ATCE	.91									
CF/ANCE	.91									
OSCF/AOSE	.86	Profitability (PFT)								
EBIT/ATL	.67									
PBT/ATL	.74									
TNI/ATL	.83									
CF/ATL	.81									
PBT/ACL	.71									
TNI/ACL	.81									
CF/ACL	.88									
FF/S	.63									
EBIT/S	.65									
PBT/S	.71									
TNI/S	.81									
CF/S	.85									

- contd

Ratio	1	2	3	4	5	6	7	8	9	10
Dr/CA		.87								
QA/CL		.76								
QA/TL		.80								
INV/CL ^S		-.57		.66						
INV/CA		-.93	Structural Liquidity (SL)							
(QA-CL)/PDOE		.66								
QA/TNW		.62								
QA/TA		.82								
Dr/Cr		.75								
Dr/INV		.89								
TL/TNW			.92							
TL/TA			.93							
TNW/TA ³			-.93							
CA/TNW			.84	Short Term Solvency (STS)						
CL/TNW			.95							
CL/TA			.93							
CA/CL				.82						
FA/TA				-.72						
WC/TNW				.83						
WC/TL				.75						
WC/NCE				.86	Short Term Asset Intensity (STAI)					
WC/Dr				.55						
AWC/S				.71						
CA/TL				.82						
CA/TA				.72						
WC/INV		.64		.51						
ATNW/S ^S			.72		.64					
VA/S					.68					
AQA/PDOE ^S		.63			.56					
ACr/COS					.75					
AQA/S ^S		.71			.57					
AINV/COS ³					.78	Turnover (TO)				
AINV/S ³					.76					
DaysDrs ^S		.65			.56					
ACA/S					.80					
S/ATA					-.86					
S/AFA ^S				.60	-.51					
S/ATCE					-.74					
S/ANCE					-.68					

- contd

Ratio	1	2	3	4	5	6	7	8	9	10
Debt/QA						-.68				
Debt/CA						-.81				
Debt/TA						-.85				
Debt/TNW						-.72	Long Term Solvency (LTS)			
Debt/TCE						-.73				
Gr/CL ³						.73				
INT/EBIT						-.57				
Total Assets							.95			
TNW							.94			
TCE							.96	Size		
NCE							.96			
Sales							.94			
VA/ATA								.80		
VA/ATCE								.69		
VA/ANCE								.66	Labour Intensity (LI)	
ER/VA ^{S,3}								.42		
ER/TA ^S								.91		
DIV/OSMI									.90	Dividend
DIV/OSEI									.53	Payout (DP)
% Variance Explained	28.2	18.8	13.2	6.8	6.0	5.2	3.5	2.6	2.4	1.7
Cum. % Variance Explained	28.2	47.0	60.3	67.1	73.0	78.3	81.8	84.3	86.8	88.5

- Notes: 1) S indicates that the ratio is classified under a dimension on the basis of its secondary loading. This was done to facilitate comparison with the manufacturing sample results and overtime.
- 2) Secondary loadings are not shown except as noted in note 1
- 3) Reciprocal transformed ratios. See Appendix 5.9 for the transformations applied to the other ratios.
- 4) All the loadings are statistically significant (See Appendix 6.4).
- 5) Loadings on components 11 and 12 are not shown since no ratio had a primary loading on either and the secondary loadings were generally very small ($<.30$)

Table 6.6: Varimax-rotated Principal components Loadings Matrix -
1977 Distribution Sample

1977 when it became part of the LTS dimension. For the distribution sample it was not a distinct dimension in any year. The ratio CL/Cr loaded consistently with the Debt ratios indicating a much closer relationship between trade creditors and debt in distribution firms than in manufacturing firms. Similarly, the composition of Short Term Solvency, especially the consistently high loadings of the ratios TL/TNW, TL/TA, CL/TNW and CL/TA on it, indicate the greater importance of current liabilities in the makeup of total liabilities in distribution firms.

6.4. 2 Profit Margin and Value Added¹³: The negative association between turnover and profit margin ratios is generally stronger in the case of the distribution sample especially in the case of FF/S and EBIT/S and the positive association with Profitability much weaker. These ratios are a measure of operating leverage¹⁴. Since operating leverage is determined by industry and sector-related factors such as cost of factor inputs the differential loadings of these ratios are a reflection of the underlying dissimilarity in some of the economic characteristics of the two sectors. This is further confirmed by the loading of VA/S on Turnover rather than on Labour Intensity. VA/S is also a function of the cost of factor inputs. Since these costs are likely to differ between the manufacturing and distribution sectors, the different dimensional affiliations of VA/S across the two sectors can plausibly be attributed to the underlying substantive economic differences.

6.4. 3 Asset Turnover: There also appears to be greater correlation among distribution firms between the turnover of inventory and turnover of total assets and capital employed as evidenced by the loadings of S/AINV and COS/AINV on Turnover. Since inventories are a major component of the asset structure of distribution firms the close correlation between the rate of utility of inventory and of the overall assets is quite in accordance with a priori reasoning.

13. All the profit margin ratios, FF/S, EBIT/S, PBT/S, TNI/S and CF/S and the value added VA/S, had loadings on Turnover ranging from .50 to .80 in the distribution sample and .30 to .50 in the manufacturing sample.

14. See Paragraphs 2.3. 5 and 2.4. 12 for a discussion of the industry influence on operating leverage.

6.4. 4 Sources of Finance: The clustering of CA/CL with the ratios representing Short Term Asset Intensity e.g. CA/TA in the case of the distribution sample implies that higher investment in current assets as a proportion of total assets (i.e. higher CA/TA) was financed by non-current liabilities (higher CA/CL). Manufacturing firms, however, appear to have had the option to finance higher current assets by either current or non-current liabilities as implied by the less strong association between CA/TA and CA/CL. The stronger association between Dr/Cr and Dr/CA in the case of the distribution sample (they both load on Structural Liquidity in this case but not in the case of the manufacturing sample), indicates that higher investment in debtors in distribution firms (as a proportion of current assets) tended to be financed by sources other than trade creditors. On the other hand, manufacturing firms appeared to be able to raise the necessary finance by trade credit or otherwise. In other words manufacturing firms appeared to possess greater flexibility in the financing options they command.

6.4. 5 Among the other dimensions Size, Labour Intensity and Dividend Payout there are no dramatic differences between the two samples. The analysis of the differences between the dimensional structures of the two samples indicates that some of these differences are related to the underlying economic attributes of the two sectors. While no rigorous conclusions can be drawn from this analysis as to those dimensions along which the two samples might be most clearly differentiated it is plausible that those dimensions which differ quite widely, might be best able to distinguish between them. We shall examine the results of our discriminant analysis in the following chapters to see whether this supposition is true.

6.5 Implications of the Dimensionality of Accounting Data

6.5 1 The financial dimensions of the manufacturing and distribution firms

derived by us are in broad agreement with some of those identified in the earlier studies of Taffler (1976), Pinches et al (1973, 1975), Johnson (1979) and Laurent (1979). A comparison of these studies in terms of their results and experimental design is presented in Appendix 6.5. Compared to the other studies ours:

- 1) is based on the largest sample size
- 2) employs both orthogonal and oblique rotations and is therefore, more rigorous (see paragraph 6.2. 6)
- 3) includes the largest number of financial ratios
- 4) covers both the manufacturing and distribution sectors and
- 5) covers a longer period than any other study except Pinches et al (1973).

6.5. 2 The financial dimensions derived by the non-U.K. studies are not strictly comparable to those in our study because of:

- 1) differences in sample size
- 2) number and composition of the ratios included
- 3) the methodology employed
- 4) the differences in economic and financial environments and
- 5) the differences in accounting and tax rules and conventions.

Despite these differences, however, we find that there appears to be a measure of agreement in the composition of the major dimensions and in the inter-dimensional correlation between our study and the American studies as shown in Appendix 6.5. Our financial dimensions display the same short term stability as was observed by Pinches et al (1975) and Johnson (1979). The broad similarity between financial dimensions across the manufacturing and distribution sectors indicated by our results is also in good agreement with the results obtained by Johnson.

6.5. 3 Although Laurent (1979, p. 413) hypothesised that the dimensionality obtained by him for the Hong Kong data would be applicable to other countries, his results differ from ours to a greater degree than those of the American studies referred to above. He did not identify a separate turnover dimension. The two orthogonal components Gearing and Long Term Solvency reported by him are represented by a single dimension Long Term Solvency in our study. Similarly, our Structural Liquidity

is represented by two of his orthogonal dimensions, Inventory Management and Credit Policy.

6.5. 4 As might be expected, the closest agreement is observed between our study and Taffler's. All his seven components have their close counterparts in our study. The invariance of the dimensions across the two studies indicates that the inter-relationships among the financial ratios are fairly stable over differing samples of firms and ratios. It also shows that the results obtained by us may not be sample sensitive.

6.5. 5 Implications for Financial Statement Analysis:

- 1) The PCA results have clearly demonstrated the considerable redundancy in the use of ratios in traditional financial analysis. The vast array of eighty seven ratios was reduced to only nine or less basic dimensions without much information loss. This suggests that the substantive aspects of a firm's financial structure may be captured by only nine or ten ratios.
- 2) We can use the results to construct a parsimonious set of ratios representing the multiple financial and economic aspects of firms. For example, we may choose one ratio (e.g. the highest loading) to represent each dimension¹⁵. If the dimensions are orthogonal the resulting ratio set will represent the basic and independent attributes of firms in a clearcut and non-redundant manner. This makes financial analysis simpler, more meaningful and rigorous¹⁶.
- 3) It was noted at the beginning of this chapter that the inclusion of collinear financial ratios in statistical models leads to the problem of multicollinearity. Additionally, it makes interpretation of the models more difficult. Models with constituent ratios to each represent a separate orthogonal dimension will, however, avoid the consequences of multicollinearity and also render interpretation easier¹⁷.

15. Alternatively, the component scores may be used to represent the orthogonal dimensions (see Child, 1976).

16. See Taffler and Sudarsanam (1980) for an example of the use of PCA in financial performance evaluation.

17. For an example of the use of PCA to select financial variables in discriminant analysis of bond rating see Pinches et al (1973 b).

- 4) The use of a multiplicity of financial ratios in the various studies reported in the literature has greatly impaired the comparability of these studies. This in turn has prevented a synthesis of the conclusions of these studies and impeded the development of a coherent theory of financial analysis. Dev's (1974) review of corporate failure prediction studies using financial ratios illustrates the problems of synthesis. She concludes her review saying that "there is no unanimity on which ratios are the best indicators of impending failure". (p. 74). The PCA results can be used to reconcile these different studies¹⁸.
- 5) The temporal stability of the interrelationship among different ratios observed in our and the American studies can be advantageously used in making valid comparisons of studies carried out at different points in time. Moreover, the apparent broad similarity in the dimensionality of accounting data in different countries confirms the validity of an international comparison of studies. Such comparisons contribute to the evolution of financial theories having wide application.

6.6. Implication of the Inter-dimensional Relationships

6.6. 1 Our analysis using both orthogonal and oblique rotations has revealed that the derived financial dimensions with a few exceptions are uncorrelated with one another¹⁹. Based on this result we may draw some tentative conclusions concerning the mutual relationship among the dimensions, and the financial performance and behaviour of U.K. manufacturing and distribution firms.

6.6. 2 Influence of Operating Scale: For the samples analysed the general orthogonality of the size dimension means that operating scale has no influence upon:

- a) the profitability (including both return on assets, (ROA) and profit margin)

18. Chen and Shimerda (1979) provide an example of using factor analytic results of earlier American studies to reconcile different corporate failure prediction studies.

19. See Tables 6.3 and 6.4.

- b) the turnover of assets
- c) the gearing
- d) the level of liquidity
- e) the level of dividend payout or
- f) the level of investment in short term assets

of both manufacturing and distribution firms. The independence of size and return on assets is in agreement with the results obtained by Whittington (1971,1980a) in the U.K., although inconsistent with the results of Samuels and Smyth (1968). However, in terms of both sample size and the number of industries analysed our study is comparable more to Whittington's than to Samuels and Smyth's ²⁰. Chen and Balke (1979) using American data also found that size had no influence on return on investment.

6.6. 3 Size, however, was significantly negatively correlated with Labour Intensity measured by value added. Since there is no difference between small and large firms in terms of return on assets or profit margin, it would appear that total wages were proportionately higher in smaller firms. Since larger firms are in general more capital intensive and, therefore, employ less labour the negative association between size and value added is quite plausible.

6.6. 4 Determinants of Return on Assets: Return on Assets was seen to be independent of size. Additionally, it appears to be unrelated to:

- a) asset turnover (measured by the Turnover dimension)
- b) gearing (measured by the solvency dimensions)

The independence of asset turnover and ROA is an interesting result since, by definition.

$ROA = \text{Profit margin} \times \text{asset turnover}.$

That is, ROA is a function of both profit margin and asset turnover. However, in our PCA the profit margin ratios together with the ROA ratios loaded highly on Profitability in both manufacturing and

20. In his 1971 study (P. 73) Whittington attributes the difference between his and Samuels and Smyth's (1968) studies to the exclusion of loss making firms from the latter's sample. This is an erroneous conclusion since such firms were included as would be clear from footnote 4, p. 134 of Samuels and Smyth's study.

distribution samples whereas, the ROA ratios were independent of Turnover. This means that profit margin is more important as a determinant of the profitability of firms than turnover. Both Pinches et al (1975) and Johnson (1979) found a similar relationship between return on assets and its components. This implies that firms in general, rely on large profit margins rather than high turnover to achieve higher levels of profitability.

- 6.6. 5 The independence of return on assets and gearing has some theoretical implications.²¹ Pinches et al (1975) found that financial leverage and return on investment were correlated although they did not report the correlation between the two dimensions in their study. They noted that this correlation

"provides an empirical basis for the a priori belief in the inter-relationship of a firm's return on investment and its use of financial leverage" (p. 302).

In the U.K., however, it would appear that the investment and financing decisions are separate and that U.K. firms do not use debt as a lever to alter their levels of profitability. This result appears contrary to the arguments concerning imperfect capital markets in which the firm financing and investment decisions are held to be inter-dependent²².

- 6.6. 6 Labour Intensity and Return on Assets: Our results show that these dimensions are independent in both the manufacturing and distribution sectors. This implies that firms which are highly labour intensive are not necessarily less efficient and profitable than the more capital intensive firms. It also means that as measures of performance - as recommended by Wood (1975) - the two dimensions will not yield the same ranking of firms.

A major component of value added is total employee remuneration which can vary widely from firm to firm depending upon the nature of

21. Under perfect capital markets without taxes the investment and financing decisions are completely separable (See Haley & Schall (1979), Chapters 11 & 12).

22. Under imperfect markets, "financing of investment becomes relevant; different investments with different risk properties may require different financing" (Haley & Schall, 1979, p. 417).

technology, degree of automation etc. There is, however, no a priori reason why firms with different levels of employee remuneration cannot produce the same return on assets employed.

6.6. 7 The lack of strong association between ROA and Dividend Payout (e.g. DIV/OSNI) in both the manufacturing and distribution samples would seem to indicate that U.K. dividend payout ratios do not directly depend on profitability. This might suggest that the more profitable firms were paying out more in absolute pounds as dividends and would imply that dividend return on capital might be higher for the more profitable firms. This inference is warranted by the positive correlation between DIV/OSE1 and Profitability ²³.

6.7 Summary and Conclusions: The analysis presented in this chapter has demonstrated the extreme redundancy in the ratio schemes employed in traditional financial analysis. It has also provided us with a rigorous means of selecting ratios which are non-collinear in a statistical sense and non-redundant in a substantive sense. We have shown that both the approach to dimensionality reduction in conventional ratio schemes advocated in the chapter and the actual empirical results presented may be of considerable potential value to financial analysts in their analysis of financial statements. Such practical benefits would appear to reside in the advantages gained of parsimony and clarity in the delineation of the fundamental financial aspects of firms and of ease of interpretation and comparability of different studies using different financial ratios both over time and in different operating environments. Some of the advantages of the data reduction will be demonstrated in the following chapters. We shall make use of the results of this chapter both in the construction of our discriminant models to minimise the problem of multicollinearity, and also in their subsequent interpretation.

23. The secondary loading of DIV/OSE1 on Profitability was, on average, .51 for the manufacturing sample and varied from .43 to .63 for the distribution sample.

Chapter 7

Financial Profiles of Manufacturing and Distribution Firms - A Discriminant Analysis

7.0. Introduction

In Chapter 2 we discussed the sources of differences and similarities among different industries and identified product, technological and demand characteristics and the market structures as some of the fundamental reasons. Distribution firms share a large community of influences like variability of demand, technological change etc. with the manufacturing firms whose products they sell and, arguably, therefore, do not constitute a separate "industry"¹. Rather, they are the essential link between the manufacturer and the consumer. Indeed, in certain industries e.g. capital goods, the distribution function is directly carried out by the manufacturer himself. (This situation must, of course, be distinguished from vertical integration where the distribution function is distinct but controlled or owned by the producer.) Thus the distinction between manufacturing and distribution is functional and not product-related.

Although distribution firms handle the same products as their manufacturing counterparts the two sectors differ in many important respects such as geographical location, requirements of capital and manpower, range of goods sold or services provided, problems of inventory control etc. These differences may be expected to have their impact upon the asset, liability and cost structures and, therefore, upon the financial performance of firms in the two sectors thus differentiating the two sectors. In this chapter we analyse the differences in the financial profiles of manufacturing and distribution firms using the statistical methodology of discriminant analysis (see Appendix 7.1 for a brief description of the technique and its salient features).

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1. It may be argued that distribution firms sell "service", a product differentiated from those of manufacturing firms. This does not invalidate our argument concerning the community of influences between the two types of firms.

The analysis is preceded by a description of the economic environment and the structure of distribution in the U.K. This is provided in the next section. The results of our analysis are interpreted in the light of the environmental and structural differences between the two sectors. The misclassifications of firms from one sector to the other by the discriminant models will be analysed with a view to making inferences concerning the Stock Exchange Industrial Classification (SEIC) system (see Section 2.2) and the degree of vertical integration in U.K. industries.

7.1. Structure of the Distribution Sector

7.1.1 We have used the term "distribution" in a wide sense to include both the wholesaling and the retailing functions. The diminished importance of small shops, the growth in the branding of manufactured goods and the increasing tendency towards forward and backward integration by manufacturers and retailers have turned wholesalers into a near extinct species (Edwards and Townsend, 1962). The distribution function is now carried out by firms of widely differing organisational structures as shown by Table 7.1.

Organisation Type	No. of Retail Businesses	No. of outlets	Persons engaged	Turnover (£millions)
Single outlet retailers	232,000	232,000	1,013,000	12,255
Multiple retailers having 2 to 9 outlets	29,000	79,000	380,000	4,790
10 or more outlets	1,700	90,000	1,210,000	18,313
Retail Trade - Total	263,000	400,000	2,602,000	35,358

Table 7.1: Organisation of Retail Trades in the U.K. in 1976

Source: Department of Trade Retailing Enquiry, 1976, Provisional Results, quoted from Retail Business, 242, April 1978.

7.1. 2 The single outlet independents accounted for 34.7% of sales against 13.5% for the small multiples and 51.8% for the larger multiples. In terms of outlets, the independent single shops accounted for 58% of the total despite doing only 35% of the trade while the larger multiples took their 52% of the trade from 23% of the shops. The average multiple shop had sales four times those of the average single outlet retailer and nearly four times above those of the average small multiple outlet. Firms in our distribution sample being quoted companies are likely to be either small or large multiples if they are retailers.

7.1. 3 The retailer's costs consist of his outlay on rent, rates, wages, lighting, heating, delivery, advertising, repairs, maintenance, depreciation etc. In addition, fixed assets in the form largely of premises, stocks and credit sales have to be financed by him. These costs and capital requirements depend upon the type of organisation of the retailer.

"Large retailing firms of both types (large shops and multiples) have generally a different cost structure from the small shops. Their rents and certain types of equipment costs and overheads are likely to be relatively higher" (Hughes and Pollard, 1957 p. 269-270).

The larger multiples may be able to take advantage of economies of scale in terms of bulk discounts, better inventory control etc. They are also able to attract higher quality labour because of better wages and career opportunities. Moreover, they may have easier access to finance either from capital markets because of their size or from their suppliers. Availability of finance will determine the investment in fixed assets, stocks etc. and influence decisions such as to own or rent premises.

7.1. 4 The financial structure of distribution firms will, of course, be affected by factors directly related to the product or products sold by them and the markets served by them. While food and grocery stores sell a limited range of close substitutes in highly localised markets, department stores sell a wide variety of goods from central

shopping areas to a diffused market. These factors will determine the investment in premises, stocks and debtors as also the wage rates and other overheads such as rates, expenses on advertising and displays etc. The overall financial profile of the distribution sector will, therefore, be determined by the relative importance of the various segments of the sector and by the relative importance of the above considerations within each segment. The major segments of the distribution sector and their share of the retail trade are shown in Table 7.2. From the brief outline of its structure it is apparent that the distribution sector is not entirely homogeneous. However, despite its diversity it may still be homogeneous vis-a-vis the manufacturing sector.

7.2. Univariate Analysis of the Differences between Manufacturing (MFG) and Distribution (DIST) Firms

7.2. 1 In order to assess the ability of the individual ratios in our data set to discriminate between the two groups a one-way analysis of variance (ANOVA) was carried out and the F - ratio was calculated for each ratio for each year. The calculated F ratios are presented in Appendix 7.2. For the two group ANOVA the associated degrees of freedom are 1 and 769 for years 1972 to 1975, 1 and 768 for 1976 and 1 and 719 for 1977. The theoretical F value at level of significance $\alpha = 0.01$ is approximately 6.80 (see Yeomans, 1976 on ANOVA and for the F tables).

Segment	Number of Businesses ('000)	Outlets ('000)	Persons Engaged ('000)	Turnover (£m)
Grocers	44	60	480	7,586
Other food retailers and off-licenses	47	66	271	4,064
Department Stores, variety and other general stores and general mail order	16	24	486	7,068
CTN	34	44	240	2,515
Footwear, clothing and textiles	34	61	303	3,869
Furniture and Household goods	33	50	276	4,007
Other non-food retailers	41	57	310	3,656
Others with retail activities	13	38	237	2,592
	263	400	2,602	35,358

Table 7.2: Retail Trade Segments in 1976.

Note: CTN = Confectioners, tobacconists, newsagents.

Source: See Table 7.1.

7.2. 2 Comparing the calculated F values for the six years we find a great deal of inter-temporal consistency in the discriminating power of the individual ratios. In Table 7.3. are listed those 58 ratios whose F values were statistically significant at 0.01 level for at least three years. Table 7.4 lists the 29 ratios which were not significant. Ratios measuring size, return on capital employed and dividend payout were, in general, unable to discriminate between manufacturing and distribution firms. This means that a small firm or a large one is as likely to engage in manufacture as in distribution². The two sectors also appear to be earning the same return on assets and capital employed. On average, manufacturing firms retained as much of their net income as the distribution firms and yielded the same dividend return as the latter. In terms of dividends, therefore, an investor can be indifferent as between firms in the two sectors³.

7.2. 3 Turning to the ratios with significant F values we find that turnover ratios have the highest discriminating power followed by ratios measuring value added or profit margin on sales. The significance of the profit margin ratios must be contrasted with the non-significance of the return on capital employed ratios. This indicates that although the cost structures of the two sectors may be significantly different they make no difference to the earning power of the assets or capital employed. Ratios representing Structural Liquidity, Short Term and Long Term Solvency and Trade Creditors are also significant discriminating ratios although the degree of their discriminating power is quite varied.

2. This conclusion needs to be qualified and restricted as our sample being composed of quoted firms does not probably include the entire range of size.

3. Investor attitude to dividends may, of course, depend on other considerations like stability, desire for current income, personal tax rate, market price etc.

1 ACr/COS	16 TNI/S	30 Dr/CA	45 TA/TNW
2 COS/AINV	17 VA/S	31 Dr/INV	46 ATNW/S
3 S/AINV	18 VA/ATA	32 CA/TA	47 CA/TL
4 AQA/PDOE	19 VA/ATCE	33 QA/TA	48 QA/CL
5 AQA/S	20 VA/ANCE	34 INV/CL	49 QA/TL
6 ACA/S	21 TA/ER	35 CA/CL	50 CL/TA
7 S/AFA	22 VA/ER	36 WC/TNW	51 DEBT/QA
8 S/ATA	23 EBIT/ATL	37 WC/TL	52 DEBT/TNW
9 S/ATCE	24 PBT/ATL	38 WC/NCE	53 DEBT/TA
10 S/ANCE	25 TNI/ATL	39 WC/Dr	54 DEBT/TCE
11 Days Drs	26 CF/ATL	40 WC/INV	55 DEBT/CA
12 FF/S	27 PBT/ACL	41 AWC/S	56 Dr/Cr
13 EBIT/S	28 TNI/ACL	42 TL/TNW	57 CL/Cr
14 PBT/S	29 CF/ACL	43 TL/TA	58 NCE
15 CF/S		44 CL/TNW	

Table 7.3: Ratios Significantly Discriminating between MFG and DIST Sectors

7.2. 4 The list of significant ratios and the relative F ratios emphasise the enormous redundancy in the ratio set. Although the F values indicate in a crude way the relative discriminating power of the ratios we have no clear indication of the relative importance of the underlying dimensions which is obscured by the redundancy among the ratios. Moreover, ratios with very high discriminating power on an univariate basis need not be equally powerful in a multivariate context when combined with the other ratios. This is the question we take up in the next section. We shall elaborate upon the economic meaning of the significant and non-significant ratios after examining the multivariate discriminant models presented below.

1 Total Assets	16 TNI/ANCE
2 TNW	17 CF/ATA
3 TCE	18 CF/ATCE
4 Sales	19 CF/ANCE
5 FF/ATCE	20 OSCF/AOSE
6 FF/ATA	21 FA/TA
7 EBIT/ATA	22 QA/TNW
8 PBT/ATA	23 CA/TNW
9 PBT/ATNW	24 INV/CA
10 PBT/ATCE	25 (QA-CL) / PDOE
11 PBT/ANCE	26 DIV/OSE 1
12 TNI/ATA	27 DIV/OSNI
13 NI/ANW	28 TNI/ATNW
14 EBIT/ATCE	29 INT/EBIT
15 TNI/ATCE	

Table 7.4: Ratios not Significantly Differentiating between MFG and DIST Sectors

7.3. 2 - Group Discriminant Analysis

7.3. 1 Linear Discriminant Analysis between the manufacturing and distribution samples for each of the years 1972 to 1977 was carried out using the Statistical Package for Social Sciences (SPSS) which provides for a stepwise procedure for the selection of variables to be included in the discriminant model. The SPSS package does not include classification procedures based on the Lachenbruch Holdout method and quadratic discriminant functions (see Section 7.5 below on these). These procedures are incorporated in a discriminant analysis package called MULDIS developed by Eisenbeis and Avery (1972; EA hereafter). This package was obtained from the University of Wisconsin and, after suitable modifications, set up on the CDC 7600 computer at the University of London Computer Centre. This versatile package permits calculation of the relative discriminating power of the variables in

the models based on the scaled-weighted discriminant coefficients (EA, 1972, p.p.67-68, also see Appendix 7.1) and also the input of a sample to be classified different from the one from which the original models were derived.

7.3. 2 Discriminant analysis has been regarded as both an analytical procedure (Cooley & Lohnes, 1971) and a classificatory procedure (Lachenbruch, 1975). As a method of analysis of the differences between group means it is an extension of the univariate ANOVA to the multivariate case. As a classificatory procedure it is used to assign observations of unknown membership to previously known groups in such a way as to minimise the error/cost of misclassification. However, this dichotomy merely obscures the complementarity of the two aspects of the discriminant analysis. The classificatory accuracy must properly be regarded as further evidence of the discriminating power of the models.

7.3. 3 The basic assumptions underlying discriminant analysis are that

- 1) the groups being investigated are discrete and identifiable
- 2) each observation in each group can be described by a set of measurements on variables and
- 3) these variables are assumed to have a multivariate normal distribution (EA, 1972, pl).

When used as a classificatory procedure it requires a further assumption concerning the equality of dispersion of the observations within each group. It also requires the specification of the classification criterion. Classification is performed subject to this criterion.

7.3. 4 We have argued in Chapter 2 that a multitude of product-related, structural and other factors operate differently on different industries thus making for fairly distinct and identifiable entities. Although some factors tend to obliterate the distinction among industries (see Section 2.7) within the broad industrial classification we have adopted in this study (see Section 2.2) the a priori assumption that industry groups and sectors are distinct appears reasonable. The assumption of multivariate normality is discussed after presentation of the models. The classification criterion chosen was the ratio of the prior probabilities of membership of the manufacturing and

distribution groups in the population (on classification criteria see Eisenbeis, 1977). Since our samples are not non-random the sample proportions may be regarded as reflecting the population proportions and hence the probabilities of membership in the populations. The groups were tested for equality of dispersion matrices and the results are presented in Section 7.5.

7.3. 5 The discriminating power of the models is determined by

- 1) the statistical significance of the Chisquare and F statistics based on Wilk's Lambda and
- 2) the rate of correct classification achieved by the models. The classificatory accuracy is, in turn, assessed by three methods:
 1. by re-classifying the original sample from which the models are derived (the original sample or OS method)
 2. by the Lachenbruch Holdout method (the LH method) and
 3. by the "predictive" method under which the annual models are used to classify the observations of the following years.The term "predictive" is used in this and the following chapters subject to the qualifications discussed in Chapter 3.

The predictive analysis will indicate

- 1) the continuing ability of the financial ratios to reflect the inter-group differences and
- 2) the stability of the groups themselves.

7.3. 6 An estimate of the classificatory power of a model based on re-classifying the original observations is likely to be biased and overly optimistic of the power of the model (Eisenbeis, 1977). The LH method which holds out one observation at a time, classifies it on the basis of the discriminant function derived from the remaining observations. This is repeated until all the observations are classified and the misclassifications are then estimated. This method is said to give an almost unbiased estimate of misclassifications (Lachenbruch, 1975, and EA, 1972). Because of its superiority the holdout method was carried out so as to confirm the results of the OS method.

7.4. Results of Discriminant Analyses

7.4. 1 In Table 7.5 are presented the six annual models along with the associated statistics and levels of significance. There are eight ratios in each model. The number of ratios in the models was limited to eight by specifying the maximum steps in the stepwise procedure as eight. It was found that increase in the discriminating power of models was quite negligible after this step. So to keep the models simple no further ratios were allowed to enter the models. Wilk's Lambda which is a measure of discrimination between the two groups has been converted into Chisquare and F statistics. Each annual model is extremely significant at $\alpha = 0.01$. (See Appendix 7.1 on tests of significance of the models).

7.4. 2 The annual models display a striking similarity in their composition in terms of their constituent ratios. The value added ratios VA/S and

1972	1973	1974	1975	1976	1977
TA/ER	VA/S	VA/S	VA/S	VA/S	VA/S ^e
CL/Cr	VA/ATA	VA/ATA	VA/ATA	VA/ATA	VA/ATA
DIV/OSMI	ACr/COS	ACr/COS	ACr/COS	ACr/COS	ACr/COS
S/ATA	S/ATCE	S/ATCE	S/ATCE	S/ATCE	Days Drs
WC/Dr	$\frac{EBIT}{ATCE}$	WC/Dr	WC/Dr	WC/Dr	WC/Dr
CA/TA	CA/CL	CA/CL	CA/CL	QA/CL	CA/CL
CF/S	CF/S	Days Drs	CF/ACL	CF/ACL	CF/ACL ^e
DEBT/TA	DEBT/TA	DEBT/TNW	TNI/ATL	CA/TNW	CL/Cr ^e
a	0.52	0.53	0.54	0.52	0.56
b	505.14	489.39	465.70	506.06	445.79
c	88.94	85.19	79.70	89.16	75.24

Table 7.5: Annual Discriminant Models and Their Discriminating Power^d

Notes: a = Wilk's Lambda; b = Chisquare; c = F statistic. The degrees of freedom for the Chisquare test are 8 and for the F test 8 and 762 for years 1972 to 1975, 8 and 761 for 1976 and 8 and 712 for 1977.

Both Chisquare and F statistics are significant at 0.001 level.

d: see footnote 4. e: see footnote 5.

VA/ATA are present in all the models except that of 1972 in which they are replaced by TA/ER which measures the same dimension "Labour Intensity" as they do (see the PCA results in Tables 6.2 and 6.6). Similarly, the ratios ACr/COS, S/ATCE, CA/CL, WC/DR and CF/ACL are also consistently good discriminators between the manufacturing and distribution sectors. The other ratios are much less consistent from year to year and do not appear to conform to any systematic pattern. Some of them drop out in one year only to re-appear in a later year e.g. Days Drs, CL/Cr.

7.4. 3 The standardised discriminant coefficients may be used as indicators of the relative importance of the ratios in the models. However, they do not provide a measure of the contribution made by each ratio to the models' discriminating power. This was calculated using the crude method suggested by Eisenbeis and Avery (1972) (see Appendix 7.1). The relative discriminating power of the ratios in each annual model based on this method and the ranking based on the standardised coefficients are shown in Table 7.6. There is striking agreement between the ranks based on the two methods, the only minor exceptions being in 1976 in the case of WC/Dr and VA/S⁶.

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4. Some of the ratios in the models may appear to be highly inter-correlated. However, of the 168 pairwise correlation coefficients among the eight discriminant ratios in the six annual models 155 were less than 0.51 while 111 were less than 0.30. In the case of VA/S and VA/ATA it was, on average, 0.56 and between CA/CL and WC/Dr it was 0.72. These ratios were allowed into the models despite their high inter-correlation since they loaded on different dimensions or had different loadings when loading on the same dimension in the manufacturing and distribution samples indicating that within each sample the ratios were not highly correlated (see Tables 6.2 and 6.6 and Appendices 6.2 and 6.4). The problems associated with collinearity are discussed in the body of the text.
 5. These ratios had signs in 1977 different from those in earlier years. Moreover their relative discriminatory powers have also changed in 1977 (see Table 7.6). These changes are probably due to the fact that the 1977 samples are different from those of the other years (see paragraph 5.1. 7 and also the notes to Appendix 5.3).
 6. It is interesting that the close agreement in the rankings by the two methods occurs despite collinearity among the ratios (see footnote 4 above). For a discussion of the measurement of relative discriminating power see paragraph 6.1. 1 and the literature referred to there.

1972	Disc. Power (%)	1973	Disc. Power (%)	1974	Disc. Power (%)	1975	Disc. Power (%)	1976	Disc. Power (%)	1977	Disc. Power (%)
S/ATA	28	VA/ATA	24	VA/ATA	20	VA/ATA	19	S/ATCE	25	ACr/COS	25
TA/ER	20	ACr/COS	19	ACr/COS	19	ACr/COS	17	VA/ATA	24	CA/CL	25
CF/S	12	CA/CL	12	CA/CL	19	TNI/ATL	16	ACr/COS	18	WC/Dr	15
CL/Cr	12	$\frac{EBIT}{ATCE}$	11	S/ATCE	16	CA/CL	15	CA/TNW	8	VA/S	12
CA/TA	11	S/ATCE	10	WC/Dr	10	S/ATCE	13	QA/CL	8	VA/ATA	8
DIV/OSNI	7	CF/S	10	$\frac{DEBT}{TNW}$	8	CF/ACL	12	CF/ACL	7	DaysDrs	8
DEBT/TA	6	VA/S	8	DaysDrs	5	WC/Dr	6	WC/Dr	5	CL/Cr	7
WC/Dr	4	DEBT/TA	5	VA/S	2	VA/S	2	VA/S	5	CF/ACL	2

Table 7.6: Relative Importance of Ratios in the Discriminant Models

Note: DISC. Power = discriminating power (Scaled-weighted method)
The rank of each ratio based on the standardised discriminant coefficient method is the same as above except in the case of WC/Dr and VA/S in 1976 their ranks being reversed.

- 7.4. 4 Interpretation of the discriminant models in terms of the dimensions represented by the discriminant ratios is rendered difficult by:
- 1) multicollinearity among the ratios (see paragraph 6.5. 5 on this) and
 - 2) inconsistency in the dimensional affiliation of some of the ratios across the manufacturing and distribution samples (see footnote 4).

The 1972 model, however, is relatively free of these problems since the highest pairwise correlation among the discriminant ratios in that year was only -0.35 between CF/S and S/ATA and there is a fairly clearcut representation of the basic dimensions in that model. The relative discriminating powers of the basic dimensions in that model are presented in Table 7.7 derived from Table 7.6 ⁷.

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7. The relative discriminating powers of the dimensions, especially, STS, STAI and SL varied considerably in the models of the other years for the reasons set forth above. Turnover, Labour Intensity and Profitability rankings were more consistent across the models and were similar to those obtained for 1972. These three dimensions accounted for 47.1 (in 1977) to 83.1 (in 1973) of the total discriminating power of all the dimensions if the relative contributions of different ratios representing the same dimension were treated as additive.

Dimension	Discriminating Power in Percent 1972	
	MFG.	DIST.
Turnover	28	28
Labour Intensity	20	20
Profitability	12	12
Short Term Solvency	4	-
Short Term Asset Intensity	11	15
Long Term Solvency	6	18
Structural Liquidity	-	-
Trade Creditors	12	-
Dividend Payout	6	6
	99	99

Table 7.7: Relative Discriminating Power of the Basic Dimensions

Note: See Appendices 6.2 and 6.4 on the dimensional affiliations of the ratios.

MFG = manufacturing; DIST = Distribution.

The totals do not equal 100 because of rounding errors.

- 7.4. 5 Validity of the Multivariate Normality Assumption: The Chisquare and F statistics are derived on the assumption that the discriminant variables are multivariate normal with the groups having common dispersions. We did not test the variables directly for multivariate normality. However, we may examine the univariate distributions of the ratios in our models to see to what extent they are normal. Where, as was pointed out in Chapter 5, the marginal distributions are non-normal, multivariate normality will not be achieved since marginal normality is a necessary condition of the latter. Our examination of the distributions of the transformed ratios (see Appendix 5.9 for the transformations applied and Appendix 5.8 for the statistics on the distributions) included in our models shows that most ratios are not normally distributed on an univariate basis. Thus they do not satisfy the necessary condition for multivariate normality.

7.4. 6 The effect of departures from multivariate normality is, however, not clear although as noted above no valid statistical inferences can be drawn. After comparing the classification errors from models based on multivariate normally distributed variables and those based on three non-multivariate transformations of these variables, Lachenbruch, Sneeringer and Revo (1973, quoted from Eisenbeis, 1977, p. 876) concluded that the standard linear procedures might be quite sensitive to non-multivariate normality. However, they suggested that "the problems may not be as great when the distributions were bounded" and that "data should be first transformed, if possible, to approximate normality". Our ratios are so bounded and transformed (see Section 5.7).

7.4. 7 Further, Gnanadesikan (1977, p. 199) remarks that

"from the viewpoint of multiresponse data analysis, symmetry of the marginal distributions of each response (i.e. variable) is not an unreasonable requisite for the meaningful use of several summary statistics such as correlation coefficients and covariance matrices. If the raw data are quite asymmetric a preliminary transformation of the observations to enhance symmetry will often be a sensible first step before the subsequent univariate or multivariate analysis that may be performed on the transformed data".

Reference to our criteria for selecting the "best" transformations (see paragraph 5.7. 10) would show that symmetry was our second most important criterion after normality.

7.4. 8 Although conformity with the assumption of multivariate normality is essential for the model's theoretical validity its practical validity cannot be judged on that score alone. In the present study we assess the latter by estimating the classificatory accuracy of the models by:

- 1) using the Lachenbruch Holdout method since the method is not sensitive to the normality assumption (Eisenbeis, 1977, p.895) and
- 2) testing the models on the samples of the subsequent years.

7.5. Classificatory Power of the Discriminant Models

7.5. 1 Estimating the correct classifications made by the discriminant functions, linear or quadratic, serves

- 1) to confirm the results of the statistical tests of the discriminant models
- 2) to assess the extent of homogeneity of the groups discriminated and
- 3) to assign observations of unknown group membership to the a priori groups.

The percentage rates of correct classification achieved by the annual models, both in each group and overall, are presented in Table 7.8.

The percentages of observations misclassified are deduced by subtracting the correct classification percentage from 100. The results of classification by the LH method are also shown alongside.

YEAR	Original Sample Method Correctly Classified in			Lachenbruch Holdout Method Correctly Classified in		
	MFG	DIST	Overall	MFG	DIST	Overall
1972	94.4	67.2	87.3	94.2	65.7	86.8
1973	95.3	67.2	88.0	95.1	67.2	87.8
1974	94.6	63.2	86.3	94.6	62.2	86.1
1975	95.4	68.2	88.3	95.3	67.2	87.9
1976	95.6	60.1	86.4	95.6	58.7	86.0
1977	92.6	65.3	85.3	92.2	64.3	84.8

Table 7.8: Classificatory Power of the Linear Discriminant Models (in %)

Note: The classification is based on prior probabilities assumed equal to the sample proportions (see paragraphs 5.1. 7 and 7.3. 4).

7.5. 2 The Lachenbruch Holdout method results are nearly identical to those of the OS method. The overall classification rates differ not more than 0.5% between the methods. The classification rates within each group are also more or less identical. The overall correct classification rate ranges from 85.3% in 1978 to 88.3% in 1976. This very high degree of discriminating power the ratios possess was indicated earlier by the Chisquare and F-statistic tests (see Table 7.5).

7.5. 3 The classificatory efficiency of the discriminant models must, however, be compared with a standard. In the absence of other criteria, this standard is appropriately a chance classification scheme. Morrison (1969) suggests two chance models:

- 1) a naive maximum chance (MC) model which assigns all observations to the largest group (in our case the Manufacturing Sector) and
- 2) the proportional chance (PC) model which assigns observations to groups with probabilities equal to group frequencies.

The PC model is, however, superior to the MC model since it attempts to classify into both groups and is, therefore, comparable to a discriminant function which "defies the odds by classifying... in the smaller group" (Morrison, 1969, p. 158). We may assess the classificatory efficiency of the discriminant models in terms of both:

- 1) the total or overall efficiency and
- 2) the conditional efficiency of classification in each group.

Of the two total efficiency is the complete and, therefore, the more appropriate measure of discriminatory efficiency (Joy and Tollefson, 1975, pp.732 - 733).

7.5. 4 The PC model's classificatory accuracy is given by $R_{pc} = \frac{\sum_{i=1}^n q_i^2}{n}$ where n = no of discriminant groups and q_i = the prior probability of group i membership.

For the manufacturing - distribution case in 1977 (see paragraph 5.1. 7 on sample sizes):

$$R_{pc} = \left(\frac{528}{721}\right)^2 + \left(\frac{193}{721}\right)^2 = 0.6080$$

The significance of the classificatory power of discriminant functions may be tested using the t - statistic (Joy and Tollefson, 1975)

$$t = \frac{R_{disc} - R_{pc}}{\sqrt{\frac{R_{pc}(1 - R_{pc})}{n}}}$$

where n = total sample size and R_{disc} = the correct classification rate of the discriminant model.

Since $R_{disc} = 85.3\%$

$$t = \frac{85.3 - 60.80}{\sqrt{\frac{60.80 \times 39.20}{721}}} = \frac{24.50}{1.8181} = 13.48 \text{ (degrees of freedom = 720)}$$

which is significant at almost 0 level of significance. Thus the least efficient annual model still has highly significant classificatory power.

- 7.5. 5 An important feature of the classification results is that nearly 95% of the manufacturing firms are correctly classified whereas only about 65% of the distribution firms are so classified. This indicates that the distribution group is considerably less homogeneous than the manufacturing group. A plausible reason for this phenomenon may be that there are far more distribution firms with significant manufacturing interests than manufacturing firms with significant distribution interests. This may be confirmed by an analysis of the firms misclassified in either sector, which we undertake in Section 7.7. Before that, however, we have to examine the statistical validity of using linear classification functions.
- 7.5. 6 Equality of Group Dispersion Matrices: When the group dispersion matrices are unequal the statistical tests of significance are only approximate (EA, 1972, p. 2). Moreover, the appropriate classification rule is a quadratic function of the discriminant variables and not a linear function. The null hypothesis of equality of the dispersion matrices was tested for each year 1972 to 1977 using MULDIS which provides for the Box test (described by EA, Appendix 1 B, p. 29) by means of an F statistic. The F ratio values, the associated degrees of freedom and the levels of significance are laid out in Table 7.9.

Year	F-statistic	Degrees of Freedom	Level of Significance
1972	23.63	36 & 505876	0.00
1973	18.82	-do-	-do-
1974	38.30	-do-	-do-
1975	33.39	-do-	-do-
1976	33.56	36 & 506172	-do-
1977	29.57	36 & 471891	-do-

Table 7.9: Tests of Equality of Group Dispersion Matrices

7.5. 7 The table shows that the manufacturing and distribution groups have significantly different dispersion matrices. Under these circumstances the appropriate classification function is the quadratic function. Accordingly quadratic classification functions were computed and observations classified using these functions. Once again both the OS and LH methods were employed. Table 7. 10 contains the rates of correct classification under each method in each year. When these rates are compared to the corresponding rate for the PC model (see paragraph 7.5. 4), we find that the discriminant functions' classificatory power is similarly significant at the 0.0 level. (The calculated t value for 1977 using the LH method result is greater than 12.71 with 720 degrees of freedom.)

YEAR	Original Sample Method Correctly classified in			Lachenbruch Holdout Method Correctly classified in		
	MFG	DIST	Overall	MFG	DIST	Overall
1972	94.4	67.8	87.4	94.0	68.7	87.4
1973	95.3	67.2	88.0	92.1	71.6	86.8
1974	94.6	63.2	86.3	94.2	65.2	86.6
1975	95.1	68.7	88.2	94.6	64.7	86.8
1976	95.6	60.1	86.4	94.2	60.7	85.5
1977	93.0	64.8	85.4	93.9	57.0	84.1

Table 7.10: Classificatory Power of the Annual Quadratic Models
(in Percent)

7.5 8 Both within-group and overall correct classification rates under the OS method are nearly identical to the corresponding rates achieved by the linear classification rule. The Lachenbruch method results, however, show some minor differences in the classification rates between the linear and quadratic rules with the greatest 1.1% in 1975 in the overall rates. The differences in the rates of correct classification within the groups, however, are slightly wider, 3.0% for the manufacturing group in 1973 and 7.3% for the distribution group in 1977 being the greatest. The bigger differences in the case of the LH method probably reflect the bias inherent in the OS method. This

bias is, in general, upward as suggested in Paragraph 7.3. 6, but quite negligible in the case of our samples of firms and the ratios in our models. It is, however, noteworthy that the quadratic classification rule does not represent any great improvement over the linear rule. This is consistent with the results of earlier researchers who found that when the two groups were well separated and the samples were large the two rules differed little in their classificatory accuracy⁸.

7.5. 9 Predictive Power of the Discriminant Ratios: If the discriminant models and ratios of one year are capable of classifying with a comparable degree of accuracy the samples of observations relating to subsequent time periods it would demonstrate that the original models are not sample-specific and thereby confirm their validity and practical usefulness. Demonstration of the predictive power may also give rise to inferences concerning the temporal stability of the groups concerned. Such likely substantive inferences are considered in the next section. Statistical inference is our main concern in this section. In testing for predictive ability both linear and quadratic classification rules were employed. In all there were 30 classifications. The rates of correct classification are shown in Table 7.11.

7.5. 10 The results show that the models have a very high predictive power with correct classifications averaging nearly 85%. There is virtually no difference between the linear and quadratic classification results. The models do seem to have suffered a small decline in their classificatory power over time. In both groups the percentage of correct classifications has declined from the base year. This decrease appears not large enough to warrant any hypothesis of significant changes in the activities of the constituent firms of either group. However, we address this question in more detail in Section 7.7 when the misclassified firms are investigated.

8. See Eisenbeis (1977) for a review of these studies.

Predicted Year	Group	1972		1973		1974		1975		1976	
		L	Q	L	Q	L	Q	L	Q	L	Q
1973	MFG	93.0	92.8								
	DIST	69.7	69.7								
	Tot	86.9	86.8								
1974	MFG	91.8	91.8	95.1	94.9						
	DIST	59.7	60.7	61.2	61.2						
	Tot	83.4	83.7	86.3	86.1						
1975	MFG	93.5	93.3	96.3	96.1	95.6	95.6				
	DIST	59.7	60.2	59.2	59.2	60.2	60.2				
	Tot	84.7	84.7	86.6	86.5	86.4	86.4				
1976	MFG	93.0	93.0	95.3	95.3	94.2	94.2	93.5	93.3		
	DIST	59.2	59.7	55.2	55.2	59.7	59.7	67.2	68.2		
	Tot	84.2	84.3	84.8	84.8	85.2	85.2	86.6	86.8		
1977	MFG	91.9	91.9	94.7	94.7	93.8	93.8	93.4	93.4	93.6	93.6
	DIST	63.7	63.7	52.9	53.9	59.6	59.6	65.8	65.8	61.1	61.1
	Tot	84.5	84.5	83.8	84.0	84.8	84.8	86.2	86.2	85.0	85.0

Table 7.11: "Predictive" Power of the Discriminant Models (Percentage of Correct Classifications)

Note: L = Linear discriminant function

Q = Quadratic discriminant function

Tot = overall classification rate; Base Year refers to the year of the model used in prediction.

Once again the classification rates are significant at the zero level compared to the proportional chance model, the calculated t statistics for 1977 exceeding 12.65 with 720 degrees of freedom.

7.6 Economic Significance of the Discriminators

- 7.6.1 The discriminant analysis results discussed above show clearly that the manufacturing and distribution firms differ significantly in terms

of financial ratios. It would not, of course, suffice merely to identify the differences. They have to be related in a causal way to the underlying economic and structural characteristics of the manufacturing and distribution sectors. Operationally we need to explain the differences in the averages of the discriminant ratios in terms of the sector characteristics.

7.6. 2 Altogether twenty ratios appeared in the six annual models although when their inter-relations were considered there were only six or seven major dimensions (see Tables 7.6 and 7.7). DIV/OSNI appeared only in 1972 and in the subsequent years it was not a statistically significant discriminator on an univariate basis (see Table 7.4 and Appendix 7.2). It is, therefore, excluded from further analysis. The remaining ratios showed very little variation in sector means from year to year. Accordingly only one set of means of the 19 ratios is shown in Table 7.12. Most of the ratios have undergone transformations to improve normality. Although these transformations might reduce the difference between the sector means their relative positions will be unaffected. The significance of the difference between the sector means on each discriminator may be assessed from the univariate F values shown alongside. The theoretical F value with 1 and 769 degrees of freedom at 0.01 is 6.80 and at 0.05, 3.90 approximately. A comparison of Tables 7.12 and 7.6 shows that those ratios which were non-significant on an univariate basis contributed only modestly to the discriminating power of the discriminant models.

7.6. 3 Sector Profiles: From an examination of the discriminant ratios and the sector means on those ratios we may summarise the comparative profile of the distribution sector as follows:
On average, the distribution sector vis-a-vis the manufacturing sector

- 1) achieves a much higher rate of utility of its assets and capital
- 2) has a much lower wage structure and adds less value
- 3) achieves greater return on capital employed but smaller cash flow
- 4) has lower working capital relying more on current liabilities
- 5) relies less on trade creditors to finance current assets and
- 6) depends more on interest-bearing debt.

Transformation	Ratio	MFG	DIS	F-ratio	Remarks Distribution Sector has
Log	S/ATA	.33	.89	299.51	higher asset turnover
"	S/ATCE	.78	1.32	181.18	higher capital turnover
Sqrt	^a ER/TA	.55	.45	92.95	lower labour intensity
-	VA/S	.35	.19	342.00	lower value added
Sqrt	VA/ATA	.71	.62	63.14	-do-
"	EBIT/ATCE	.72	.75	16.53	higher return on capital
Log	^{1,2} TNI/ATL	-.78	-.82	3.63	lower net income
"	² CF/S	-.57	-.62	88.98	lower cash flow
"	² CF/ACL	-.41	-.49	21.33	-do-
"	CA/CL	.46	.26	64.61	lower working capital
"	QA/CL	-.18	-.51	75.18	lower liquidity
"	² WC/Dr	4.18	4.17	18.34	lower working capital
-	¹ CA/TA	.62	.61	.04	lower current assets
-	Days Drs	72.81	48.76	118.43	less trade debtors
Sqrt	ACr/COS	.42	.34	172.99	less trade creditors
-	^a Cr/CL	.56	.52	8.82	-do-
-	¹ DEBT/TA	.16	.18	2.96	higher debt dependence
Sqrt	¹ DEBT/TNW	.58	.62	1.96	-do-
Log	¹ CA/TNW	.25	.29	1.40	higher gearing

Table 7.12: Sector Means on the Discriminating Ratios

Note: a = reciprocals of original ratios (see Appendix 5.9)

1 = these ratios are not significant at 0.05. All the other ratios are significant at 0.01.

2 = these ratios were transformed after adding constants to avoid negative values. The constants were: for CF/S, .5010; CF/ACL, .4582; TNI/ATL, .3151; WC/Dr, 64.1579.

7.6. 4 Turnover of Assets and Capital: The higher turnover of assets in the distribution sector may be explained in terms of the turnover ratios e.g. Sales/Average Total Assets (S/ATA).

The amount of assets employed by firms in the distribution sector is likely to be much less than that employed by their manufacturing

counterparts. Distribution firms need not invest in production-related assets such as plant and machinery, Research and Development facilities etc. On the other hand, they probably need to invest more in premises. Indeed their fixed assets are probably completely made up of freehold or leasehold premises apart from fixtures and fittings.

7.6. 5 The average distribution firm's investment in premises and fixtures and fittings may equal or exceed the average manufacturing firm's investment in premises, plant and machinery and other fixed assets. Although distribution firms' fixed assets are largely limited to premises, these premises are likely to be situated in prime shopping areas. Should the distribution sector's investment in premises equal the manufacturing sector's investment in different types of fixed assets the rates of turnover of fixed assets may not differ widely between the sectors. An F-statistic test of the difference between the mean fixed asset turnovers of the two sectors, however, shows that it is statistically highly significant. The average fixed asset turnover, S/AFA, in 1975 was 1.60 for the manufacturing and 2.10 for the distribution sector, these values being very similar in the other years (these values are log transformed values). The calculated F value is 72.3 which considerably exceeds the theoretical F value of 6.80 at less than 0.01 (the degrees of freedom are 1 and 769).

7.6. 6 The smaller fixed asset base of the distribution firms may also be due to "off-balance sheet" financing to which premises are particularly amenable. They lend themselves much more easily to sale and leaseback arrangements. The importance of sale and leaseback method of financing premises was noted by Evely (1959) while studying the changes in the net tangible fixed assets of quoted U.K. retail firms for the period 1949-53. "Properties were often sold to insurance companies or other long term investors and then rented back from them, so releasing resources for expansion in other ways". He observed that for "the mixed distributors and the general stores groups there was net disinvestment in fixed assets during this period" and that compared to all quoted companies there was a "relatively small increase in fixed assets among retail companies" (pp.243-244).

7.6. 7 A more recent study by George and Hills (1968) of productivity and capital expenditure in retailing lends support to Evelyn's results. George and Hills analysed, inter alia, the investment made by 35 of the largest U.K. retail firms in fixed assets between 1961 and 1966. Although it is not known how many of the firms in their sample were quoted, they are comparable to our sample of quoted firms in terms of size. Their sample was divided into Co-operatives (not included in our sample), Department Stores, Grocers, Confectioners, Tobacconists and Newsagents (CTN) and others. They estimated the capital value of rented premises and sale and leaseback transactions as being ten times the rent payable.

7.6. 8 Their estimates showed that

"of the £222 million of fixed assets in 1961 approximately £33 million (i.e. one-seventh) was the capitalised value of rented premises. The importance of rented premises was much greater for the confectioners, tobacconists, newsagents group where out of £18 million of fixed assets, £13 million was the capitalised value of the annual rent payment....For all the firms the value of newly rented premises (over the period 1961-66) accounted for approximately 17% of the increase in fixed assets, a figure which also reflects the approximate importance of new rented property in the grocers and "other" categories" (p.22).

They noted that

"in retailing, a great deal of expansion can be financed out of cash flow, especially when new property is rented"

and that

"the renting and sale and leaseback of property can make an appreciable difference to the capital expenditure - increase in sales relationship" (p.77; see also their table 10.5).

7.6. 9 It may be recalled from Table 7.2 that Grocers and other Food retailers and off-licenses accounted for 33% and the CTN group for 7.1% of total distribution turnover in 1976. They also had 170,000 of the total 400,000 retail outlets. They thus form a major segment of the distribution sector. The food retailing, grocery and general food firms are strongly represented in our sample accounting

for 35 out of 201 firms. In our sample are included the CTN group firms such as Martin the Newsagent, Menzies (John) (Hldgs), NSS Newsagents and Smith (W.H.) and Sons (Hldgs). If the tendency to rent premises was quite strong in these sectors as was observed by George and Hills for their sample it would contribute in a large measure to the difference in the asset and capital turnover rates between the manufacturing and distribution sectors in our sample. Another segment of the distribution sector which operates on a small fixed asset base is that of mail order firms which have no need of well equipped shops in expensive shopping areas. These firms accounted for a turnover of £1805 million in 1977 which was 4.9% of all retail and 8.6% of all non-food retail sales (Retail Business, August 1978). Our sample includes 5 of these firms (Appendix 7.4). They would also contribute to the higher sales to capital ratio in the distribution sector.

7.6. 10 Investment in Current Assets: The distribution sector is also likely to have less investment in current assets than the manufacturing sector. As regards inventory, the manufacturing firms' inventory consists of raw materials, work-in-progress and finished goods whereas the distribution firms' inventory consists of either semi-finished goods to be supplied to manufacturers (e.g. timber, steel etc.) or, more widely, finished goods. At any point in time the total manufactured output of goods available to the consumers will be on stock with either the manufacturers or the distributors. No statistics are available as to the proportion in which the total stock is divided between the two. In determining the level of stock the manufacturer has to consider the expected demand for his goods, length of production runs, the amount of capital locked up in stock etc. whereas the distributor's stock will be influenced by considerations of expected demand, ease of access to additional stocks when required, amount of capital required to finance the stock and the cost of storage.

7.6.11 Given the fact that retailers generally operate in central shopping areas the constraint of storage cost on them is a crucial consideration. For this reason they would endeavour to maintain minimum stock subject to the other considerations stated above. The level of stock will,

of course, depend on the product. Stocks of food, groceries etc. with retailers will be small. In these sectors the retailer will have considerably lower stocks than his manufacturing counterpart. Heavy engineering and capital goods are often sold directly to the consumers by the manufacturers. Stocks of these goods in the distribution sector will, therefore, be nearly non-existent. Thus it would be reasonable to conclude that the stock of finished goods would be larger in the manufacturing than in the distribution sector.

7.6. 12 In addition to the finished stocks, manufacturing firms also hold stocks of raw materials and work-in-progress unlike distribution firms. As a result the manufacturing firm's investment in inventory is likely to be much higher. Given this investment in inventory, the manufacturing firms will have a smaller turnover of inventory. For our sample the mean value of the ratio Average Inventory/Sales (AINV/S) in 1975 for the manufacturing sector was 0.46 and for the distribution sector 0.36, the values for the other years being similar (these values are square-root transformed values). The difference in the means is statistically significant at $p = 0.01$, the calculated F ratio at 176.2 exceeding the theoretical F of about 6.80 with 1 and 769 degrees of freedom.

7.6. 13 Investment in Debtors: The distribution sector's investment in trade debtors is also likely to be much less than the manufacturing sector's. Although wholesalers extend credit to retailers, credit sales by retailers are on a much smaller scale. Credit sales depend on the type and value of the goods as well as the customs of particular trades. In the case of small value consumer items they are likely to be very much smaller (e.g. food) than in the case of high value consumer durables (e.g. refrigerators, electronic goods and the like). Although with the spread of bankers' credit cards retailers credit sales have increased they are small in volume and in terms of the length of credit period. Instalment credit sales by retailers increased from £1,130 millions in 1971 to £2,520 millions in 1977. Yet, they were only 7% of the total retail turnover and 12% of the non-food shops' sales in 1977 (Retail Business, Annual Review of Retailing, 1978).

7.6. 14 Since the bulk of retail sales is for cash the investment in debtors

in the distribution sector is likely to be less than in the manufacturing sector. This is confirmed for our sample by the statistically significant difference in the mean values of Days Drs for the two sectors. For the distribution sector the number of days debtors outstanding was on average 48.76 and for the manufacturing sector, 72.81. The $F_{calc.}$ at 118.43 with 1 and 769 degrees of freedom was significant at less than 0.01. Thus the distribution firms achieved a higher rate of turnover of debtors than the manufacturing firms.

7.6. 15 From the above analysis it is clear that the higher rate of total asset turnover in the distribution sector is due to a higher rate of turnover of the major categories of assets which make up the total assets viz. fixed assets, inventory and debtors. We have shown that the lower investment in each of these asset categories in the distribution sector is due to economic considerations which, in turn, are derived from the nature of operations of that sector. The various turnover ratios in our data have thus reflected the underlying operational characteristics of the manufacturing and distribution sectors.

7.6. 16 Wages and Added Value: This is the second major aspect of the sector profile revealed by our analysis. There are two basic reasons for the smaller value added in the distribution sector:-

- 1) the nature of activity of the sector and
- 2) the composition of the workforce.

Manufacturing involves product conversion from raw material to the finished product. It is a process which is a function of technology and therefore, requires a highly skilled workforce. It is also a process which is characterised by continuity and fairly stable work patterns. On the other hand, distribution is an activity involving no product conversion and, therefore, does not require a technically skilled workforce. The wage rates and the total wage bill in the distribution sector will, therefore, be less. So will the value added.

7.6. 17 The composition of the workforce in the distribution sector also tends to push the wage rates down. It is determined not only by the level of technical skills required but also by the discontinuous nature of the

selling activity in the sector. The latter arises from the fact that demand for the distributors' services is characterised by peaks and troughs. Because of this the distributive trades, especially the retail trades, attract part-timers and "birds of passage" moving on to more stable and better paid jobs in other industries.

"Retailing provides good opportunities for and can count on good supplies of women and young people who are on the fringe of the labour market, in the sense that they do not want to make permanent full-time careers in retailing" (McAnally, 1971).

The concentration of activity at certain times of day, week or year and the technically undemanding nature of the job are thus well-suited for temporary and part-time job seekers. Over 30% of the workforce in retail trade is employed on a part-time basis. The greater importance of part-time working in the large establishments of multiples is apparently due entirely to the greater importance in this type of shop of "Saturday-only" workers employed to cope with the problem of peak demand (George, 1966). Part-timers amounted to 25% of the persons engaged in department stores and 45.9% of those in larger grocers in 1966 (McAnally, 1971, p. 131).

7.6.18 Owing to these factors the distributive trades are considerably behind most manufacturing industries in terms of average employee remuneration. Ranking sectors in terms of wages and productivity as part of an industrial performance analysis, Inter-Company Comparison (1978) found that in 1976-77, Supermarkets, Department Stores, Grocery Wholesalers and Electrical Wholesalers were among the ten lowest ranking sectors. The lower value added by the distribution sector is, therefore, attributable to the nature of the workforce, its composition and the lower wage rates received by it. The discrimination between the two sectors in terms of value added ratios is thus entirely consistent with the underlying structural characteristics of these sectors.

7.6.19 Return on Capital and Cash Flow: These factors are much less important than turnover and value added in the sector profile. Only one of the six annual models (the 1973 model) contains a return on capital ratio (EBIT/ATCE) which accounts for only 11% of the discriminating power of

that model (see Table 7.6). Moreover, it may be recalled from the univariate analysis of the discriminating ability of the individual ratios that the return on assets and return on capital ratios were not consistent or strong discriminators (Section 7.2). The cash flow ratios, however, were more significant discriminators on both univariate and multivariate bases. We shall, therefore, limit our discussion here to them. Cash flow which is the sum of retained income and depreciation is a function of the cost structure or operating leverage and the structure of assets. Compared to the other profit margin ratios FF/S , $EBIT/S$, PBT/S and TNI/S , CF/S has the highest discriminating power which enables it to enter our discriminant models. This reflects the impact of the differential cost structures between the manufacturing and distribution sectors.

7.6. 20 The major elements of operating leverage, apart from wages which we have already discussed, are rents, interest and depreciation. We have shown at length the greater importance of rented premises to the distribution sector (see paragraphs 7.6.6 to 7.6.9). Rents will, therefore, form a more significant part of the overheads in that sector than in the manufacturing sector. Depreciation charge is determined by the amount of wasting assets employed by firms. We have already provided some evidence that the distribution sector's fixed assets are made up largely of premises whereas the manufacturing sector is heavily invested in plant and machinery and other intangible assets such as R & D expenditure which have to be depreciated or written down. While leasehold premises in the distribution sector may be written down the depreciation charge is unlikely to be as significant as in the manufacturing sector. Related to the structure of assets is the amount of capital allowances. Since these allowances will be higher for the manufacturing firms cash outflow on account of tax will be less. With this advantage manufacturing firms will have higher cash flow.

7.6. 21 The importance of interest charge or income leverage will be determined by the amount of interest bearing debt in the financial structure of firms. Greater reliance on debt is one of the distinguishing features of the distribution sector as seen from the sector profile (paragraph 7.6.3). The principal components analysis discussed in the last chapter indicates that the debt ratios are more strongly negatively

correlated with the return on assets and cash flow ratios in the case of distribution firms than in the case of manufacturing firms⁹. There is thus evidence that interest charge is a more significant component of the cost structure of distribution firms. We discuss the differences in the financing mix of the two sectors in greater detail below. Here we may conclude that the cash flow ratios are able to reflect the differences in the fundamental factors determining the cost structures of the two sectors.

7.6. 22 Sources of Finance: The remaining three aspects of the sector profile are relatively minor and concerned with the way the two sectors finance their current assets. The manufacturing sector relies less on current liabilities but more on trade creditors to finance its current assets. This seeming paradox is resolved when interest bearing short term debt such as bank overdraft and loans are taken into account. Our empirical results fly in the face of the commonly held notion that the wholesaler and retailer are able to receive enough trade credit from the manufacturer to finance their stocks and credit sales.

7.6. 23 This is, however, consistent with the findings of Whittington (1971). He compared, among others, the current ratio (CA/CL) and the net trade credit given (Dr-Cr) in four industries, Clothing and Footwear, Food, Wholesaling and Retailing. His results show that the current ratio was consistently smaller for the Wholesaling and Retailing firms than for the two manufacturing industries over the period 1949-60, the gap widening in the closing years (see his tables A.7.1 to A.7.4). He concluded that

"on average, Wholesaling companies were the biggest givers of Net Trade Credit and Retailers and Clothing and Footwear firms gave least. In view of the large amount of trade credit given by Wholesalers and manufacturers, and the fact that much of the turnover of retailers is for cash, it is surprising that most of the retailers were net givers of trade credit" (p. 178).

9. This observation is based on the secondary loadings of the debt ratios on Profitability. For example, the secondary loading of Debt/TA on Profitability is, on average, 0.45 for the distribution sample and less than 0.25 for the manufacturing sample.

7.6. 24 Whittington's results show that wholesalers make less use of trade credit to finance their debtors¹⁰. When inventory is also considered the reliance of the distributors on trade credit to finance their current assets is even more sharply reduced. It would appear that banks and medium or long term lenders are relatively more important as sources of finance to the distributor than to the manufacturer. Analysing the sources and uses of funds for 42 large retail companies over the period 1961-65, George and Hills (1968) found that "there is a rough correspondence between fixed capital expenditure and cash flow, between credit received and given and between the increase in stocks and long term loans". For this period bank finance amounted to nearly 20% of the increase in stocks (see their table 9.3. p. 61).

7.6.25 The reliance on bank and other non-trade sources of finance may be much higher in some segments of the distribution sector than in others. In the motor trade which accounts for 38 out of 201 firms in our sample car manufacturers

"insist on early payment or even payment in advance from their distributors.....This means that the distributors have to command large financial resources in order to pay promptly for the cars - which must be then displayed, sold and eventually paid for before the cash cycle is complete" (Samuels and Wilkes, 1980, p. 295).

The increasing importance of sales on instalment credit and hire-purchase etc. in the case of durable consumer goods means that distributors have to rely on non-trade sources of finance. Trade credit, being essentially of a short term nature, may be unavailable to finance these medium term book debts.

7.6. 26 The above analysis of the sector profiles confirms that the differences identified by the discriminant models between an average manufacturing firm and an average distribution firm are generally related to the

10. Stowe et al (1980) in their canonical correlation analysis of the balance sheet variables for a sample of American firms found a high degree of matching between inventories and accounts payable and between accounts receivable and other current debt. It is not, however, clear whether their sample is pure manufacturing or distribution.

economic, operational and structural characteristics of the two sectors. While this conclusion is true of the average firm in either sector, there may be firms which are quite unlike the average. The manufacturing sector comprises industries of varying product, technology and market characteristics. Similarly, the distribution sector has a wide variety of organisational structures as shown in Section 7.1 although all these organisations are concerned essentially with their role as a conduit between the producer/manufacturer and the consumer. The diversity within each sector may cause dissimilarity in the financial profiles of firms and lead to their being misclassified.

7.7 Analysis of Misclassified Firms

- 7.7. 1 Classification of firms using the discriminant ratios resulted in about 5% of the manufacturing and 35% of the distribution firms being misclassified (see Section 7.5). The misclassifications may, of course, be attributed to lack of sufficient discriminant power in our ratios. Given the high percentage of correct classifications and the large number of ratios representing widely varying facets of firms, the argument of insufficiency of discriminating power in our ratios is, however, perhaps unsustainable. In the case of some individual companies, the computed ratios may not reflect the "true" position for want of adequate detail in the financial statements and thus may cause those companies to be assigned incorrectly. However, the extent of misclassifications arising from this is likely to be small. An alternative explanation of misclassifications is that there is a large degree of cross-sector diversification or, in other words, vertical integration of manufacturing and distribution activities in some firms. The much higher rate of misclassification of distribution firms might suggest that backward integration from distribution to manufacturing is probably more prevalent than forward integration from manufacturing to distribution¹¹.

11. It must be noted that our assignment of firms to manufacturing and distribution sectors was somewhat arbitrary (see paragraph 5.1.5) and could have resulted in some misclassifications. The following analysis encompasses these probable misclassifications also. Also, the misclassifications may have been due to the non-conformity of our data with the statistical assumptions of discriminant analysis. (See Section 7.4). However, the consistency of our results across three different

- 7.7. 2 Misclassifications by the discriminant models were examined for all the six years of our study. Twenty nine manufacturing firms and 73 distribution firms were misclassified in at least three years while the average number of misclassifications over the six year period was 30 and 70 respectively. This means that the misclassified firms were consistently misclassified. The 29 manufacturing firms, their SEIC industry codes and broad industry descriptions are given in Appendix 7.3 along with the size of these industries in our sample.
- 7.7. 3 In the appendix are also shown, where available from published financial statements, the proportion of turnover attributable to distribution or overseas sales. Such data were, however, available in the case of only a small number of firms. The largest number of misclassifications occurred in the Food and related industries i.e. 12 out of a sample of 28. Misclassifications in Metallurgy, General Chemicals and Oil numbering three each are very small compared to the respective industry sample sizes and seem to be derived from the idiosyncratic financial profiles of the individual firms rather than a systematic industry-related pattern. In the case of Tricentrol in the Oil industry available data suggest that a substantial part of its turnover may be accounted for by transportation and distribution probably causing the misclassification.
- 7.7. 4 A possible cause of misclassification is the overseas activities of firms. Since U.K. firms are not required to disclose the number or remuneration of their overseas employees the value added ratios computed by us using published accounts might be understated. Appendix 7.3 also shows the value of Value Added/Sales (VA/S) in 1975 for those firms which have a significant amount of overseas operations. Comparing their values with the sector means of VA/S (see Table 7.12) we see that these firms are closer to the average distribution firm than to the average manufacturing firm. In the case of these firms weakness of accounting data appears to have led to error. However, the impact of such weakness must not be exaggerated in view of the very small number of misclassifications that may be attributed to it.
- 7.7. 5 The misclassification of three holding companies and one Transport company and one Footwear is more easily attributed to the large share of their

11 (contd) validation techniques and two classification rules suggests that the reasons for the observed misclassifications are substantive rather than merely statistical.

distribution activity and/or their significant overseas exposure. Medminster, a furnishing store and Helene of London, a multiple both have non-manufacturing activities which probably account for their misclassification.

- 7.7. 6 Misclassified firms in Food and related industries appear to be engaged in both manufacturing and distribution. The proportion of these activities in the case of Associated British Foods, Basset (Geo) Holdgs, Feedex and Tate and Lyle indicate that distribution accounts for at least 20% of their turnover. Moreover, Associated British Foods, Lyons (J) and Co., Spillers, Tate and Lyle and Unilever have considerable overseas production/distribution activities which, for the reasons set out in paragraph 7.7.4 might at least partially explain their misclassification.
- 7.7. 7 There is thus a much greater degree of forward integration in Food and related industries than in others. It was noted by Pickering (1976) that vertical integration is a highly important influence on the structure of a number of major industries including flour, milling and baking and that "in the flour milling and bread baking industry, each of the five major baking groups obtains nearly all its flour from within its own group" (p. 54). Our analysis suggests that this vertical integration also extends to distribution. Other industries in our sample exhibit little or no forward integration.
- 7.7. 8 Misclassification in the Distribution Sector: Although, as noted earlier, 73 distribution firms were found to be consistently misclassified seven segments of the sector accounted for 50 of these firms. The remaining 23 were spread over nearly 12 industries indicating that they were not related to systematic industry factors. Hence we limit our discussion here to the seven distribution segments whose misclassifications point to a definable pattern. The misclassified firms are listed in Appendix 7.4 along with their industry codes and descriptions.
- 7.7. 9 The misclassified firms also accounted for 61% of the total sample size of the seven segments as shown in Table 7. 13.

Segment	SEIC Industry Code	Number of Mis- classifications	Sample Size
Builders Merchants (B.M.)	13	6	14
Timber (Timb.)	17	7	9
Special Steels (S.S.)	33	4	6
Department Stores (D.S.)	55	7	13
Furnishing Stores (F.S.)	56	6	7
Mail Order Stores (M.O.)	57	5	5
Multiple Stores (Mult)	58	15	28
Total		50	82

Table 7.13: Segmental Distribution of Misclassified Distribution Firms

- 7.7. 10 Sufficient information is not available in the published financial statements of these firms to determine the extent of manufacturing that they carry out. It, however, appears from the broad sweep description of their activities that almost half of them, especially those in Timber, Builders Merchants and Special Steels, have significant manufacturing activities. The other four segments comprising the stores have considerably smaller levels of manufacturing activity. The reasons for their misclassification have, therefore, to be explored outside the context of vertical integration.
- 7.7. 11 Appendix 7.4 contains the values of the misclassified firms on 6 selected untransformed ratios in 1975. These may be used to assess approximately the extent of similarity of the misclassified firms to the average manufacturing firm (AMF) and to provide some insight into the financial structure of the misclassified distribution segments. Four of these ratios, S/ATCE, VA/S, Days Drs, CA/CL were highly significant discriminators (see Table 7.12). The other two ratios S/AFA and S/AINV are intended to provide additional insight into which asset categories cause the firms to resemble the AMF. The value of the misclassified firms on these ratios may be compared to the manufacturing and distribution sector means (i.e. the AMF and the ADF, the average distribution firm). Since our interest centres on the segments and not on the individual firms we may represent each segment

on each ratio by the median for that segment and compare the medians with the sector means. From this admittedly crude comparison we may gain some understanding of the segment profile in relation to the average firm in either sector. In Table 7.14 are provided the segment medians and the sector means on the six ratios.

Ratio	Sector Means		Distribution Segment						
	MFG	DIST	Timb	B.M.	S.S.	D.S.	F.S.	M.O.	Mult.
S/ATCE	2.18	3.74	2.81	2.39	2.53	1.55	2.08	2.87	2.50
S/AFA	4.75	8.17	5.34	5.29	6.03	4.22	4.60	8.88	3.73
S/AINV	4.73	7.72	4.17	5.22	5.29	5.98	7.88	5.48	5.32
Days Drs	72.81	48.76	73.52	64.70	73.76	64.06	109.57	109.22	53.96
VA/S	.35	.19	.18	.20	.18	.27	.23	.18	.30
CA/CL	1.58	1.30	1.62	1.42	1.35	1.58	1.48	1.49	1.59

Table 7.14: Medians of Misclassified Segments on Selected Ratios

Note: The sector means have been derived from the transformed values shown in Table 7.12 and in paragraphs 7.6. 5 and 7.6. 12 by de-transforming them. The means so derived will not necessarily be the same as those calculated on the basis of raw untransformed ratios.

For key to abbreviations see Table 7.13.

7.7. 12 Our discussion of the sector profiles indicated that the manufacturing sector employed more assets and capital and that it also invested more in each of the major asset categories - fixed assets, inventory and debtors. From the median values on the capital turnover ratio S/ATCE it appears that the segments are closer to the AMF than to the average distribution firm (ADF). Indeed Department Stores and Furnishing Stores have a lower capital turnover and higher capital intensity than the AMF. This implies that the segments' asset base is as large as the AMF's. But in terms of fixed assets (S/AFA) Department Stores, Furnishing Stores and Multiples appear to have invested more heavily whereas Mail Order firms less than the AMF. In fact Mail Order firms' investment in fixed assets is even less than that of the ADF. The

fixed asset structure of the stores is quite plausible in terms of their operating characteristics with the Department, Furnishing and Multiple stores having to operate in central shopping areas from premises large enough to hold large stocks. Moreover their fixtures and fittings appear from balance sheet figures to account for a substantial portion of fixed assets, often up to 20%. On the other hand, Mail Order firms have no need of large premises and can operate away from shopping areas as we discussed in Paragraph 7.6.9.

7.7. 13 In terms of inventory, the stores appear to have invested less than the AMF. Furnishing Stores in fact have no more inventory than the ADF. This accords to some extent with the arguments put forward in paragraphs 7.6.10 to 7.6.12 that the distribution sector is likely to have smaller stocks than the manufacturing sector¹². However, the higher inventory holding of the other stores compared to the distribution sector may arise from the fact that they normally hold a wide range of consumer durable and semi-durable goods of high unit value. The wider the range the more attractive to the shopper the stores are. In the case of multiples, the same or nearly the same range of goods is likely to be held in each outlet thus necessitating a large overall stock. Thus wide diversity of goods, the multiplicity of outlets and the high unit value of goods sold may plausibly account for the large investment in stock in the stores. Level of inventory will also be enhanced in the case of those multiples which have significant manufacturing activity such as tailors, men's and women's wear stores.

7.7. 14 As regards debtors, the Department and Multiple stores have the lowest and the Furnishing and Mail Order firms the highest investment in debtors. Mail Order firms typically operate by selling on instalment credit basis. Furnishing stores sell high unit value goods like furniture and also provide extensive instalment credit facilities. The Department and Multiple stores sell a mixture of high value and low value goods and thus are likely to have a smaller volume of credit

12. It is also the trade custom in the furniture business for the manufacturer to maintain the stocks in the wholesalers/retailers' show rooms.

sales and a lower level of debtors. In 1977 credit sales accounted for 86.9% of all mail order houses' turnover, which compares with 13½% for durable goods shops, 13% for department stores and a negligible percentage for clothing and footwear shops (Retail Business, 246, August 1978). Our results reflect this general pattern. In terms of Value Added/Sales, among the stores only Multiples appear to be closer to the AMF, the others resembling the distribution sector. We have already explained the low added value in the distribution sector in terms of the low total wage bill and the average wage of employees (see paragraphs 7.6.16 to 18). However in terms of reliance on current liabilities to finance current assets the stores are more like the manufacturing sector. In view of their larger investment in long term assets they seem to rely more on long term capital and less on short term overdrafts and loans than the ADF. The proximity of the stores to the manufacturing sector profile is thus largely due to their large asset base dictated by their organisational structure and operating characteristics.

7.7.15 Timber, Builders Merchants and Special Steels are segments distinguished from the stores in that they sell semi-processed or intermediate goods and not finished goods. Firms in these industries often carry out processing of the materials which they subsequently sell. In the absence of a detailed breakdown of their processing and distribution activities in published accounts a crude indication of the importance of processing to these firms may be gained from the ratio Plant and Equipment/Investment in Buildings. This ratio is obviously likely to be large for manufacturing and processing firms. In Appendix 7.4 the ratio values for the firms in the three segments are shown. They indicate that almost all the firms engaged in considerable processing and manufacture.

7.7.16 In the timber trade some firms (e.g. Sabah Timber) hold licenses for extraction of timber which involve a large investment in land. Almost all the firms in our sample undertake manufacture of timber products like veneered panels, roof trusses, softwoods etc. Builders merchants manufacture architectural and sheet metalwork (e.g. Cakebread Robey), plumbers' brassware (e.g. Randalls), aluminium windows (e.g. UBM).

Similarly the special steel stockholders process steel to produce special types of steel like stainless steel (e.g. Brown and Tawse) or carry out rolling of steel (e.g. Lilleshall).

- 7.7. 17 The large degree of vertical integration in the three segments arises from the specialist nature of their products. These products are subject to considerable technological innovations which lead to new products and new uses for old products. Changes in building techniques and architecture are reflected in changes in the products sold by the timber and builders merchants e.g. veneered wood panels, aluminium windows etc. Pickering (1976) has hypothesised that vertical integration may be a function of the age of the industry.

"There may well be a life cycle element. In the early days of an industry there is often no specialist supply industry so manufacturers must engage in some backward integration producing their own semi-finished goods or components" (p.55).

Our analysis seems to provide some evidence of this happening in the Timber, Builders Merchants and Special Steels segments.

7.8 Summary and Conclusions

- 7.8. 1 In this chapter we analysed the differences between manufacturing and distribution firms as reflected in their financial ratios using both univariate analysis of variance and stepwise multivariate discriminant analysis. The ratios identified by the discriminant analysis were generally those suggested by the univariate analysis. Comparison of the univariate and multivariate analysis, however, reveals the considerable redundancy in our ratio set. In terms of their relative discriminating power ratios representing Asset Turnover and Labour Intensity were the most important accounting for nearly 50% of the total discriminating power of the annual models. Cash Flow and Short Term Solvency also had substantial discriminating power. The models displayed little bias in classification as confirmed by the Lachenbruch Holdout tests but considerable stability over time in terms of their predictive power. Linear models were as good as quadratic models despite the dissimilarity of the group dispersion matrices. The

profiles of the manufacturing and distribution sectors based on the discriminant ratios were found to be related to the underlying economic and structural characteristics of the two sectors. Analysis of the misclassified firms lent corroboration to the economically meaningful nature of the discriminant ratios.

7.8. 2 Our analysis has achieved the first three objectives set forth in Chapter 1, (Section 1.3). As regards the fourth, the level of aggregation in industrial classification, it would appear that in the case of the following SEIC industries the division between manufacturing and distribution sectors may not be clearcut.

- 1) General Food Manufacturing
- 2) Milling and Flour and Confectionery
- 3) Timber
- 4) Special Steels
- 5) Department Stores
- 6) Furnishing Stores
- 7) Mail Order Stores
- 8) Multiple Stores and
- 9) Builders Merchants

For the purpose of ratio analysis, therefore, the above industries must largely be treated as manufacturing or as separate sectors. The reasons for cross-sector affinity were, however, different for different sectors. In the case of Food and related industries, Timber, Builders Merchants and Special Steels the affinity appears to be accounted for by considerable vertical integration. In the case of stores, however, it resides more in their organisational structure and operating characteristics.

7.8. 3 The analysis of differences between the manufacturing and distribution sectors has clearly established the descriptive ability of financial ratios satisfying the test set up in Chapter 3 in this regard. It has also revealed a very high degree of homogeneity within the manufacturing sector. This was vis-a-vis the distribution sector. But among the manufacturing industries themselves there are considerable variations related to the factors discussed in Chapter 2. In the next chapter we investigate whether these variations are reflected in the accounting numbers of firms providing additional evidence of their descriptive ability.

Differential Financial Characteristics of Manufacturing Industries

8.0. Introduction

The discriminant analysis results presented in the last chapter clearly demonstrated that accounting numbers had significant descriptive ability in reflecting some of the industry-determined substantive economic differences between the manufacturing and distribution sectors. Such demonstration does not necessarily imply that accounting numbers can also delineate the substantive differences among manufacturing industries or among distribution segments. As argued in Chapter 2 there are, a priori, substantive differences among different industries. It is our objective in this chapter to examine whether accounting numbers possess descriptive ability (as defined in Chapter 3) in the context of a group of manufacturing industries.

This chapter presents the results of discriminant analyses of a sample of 14 manufacturing industries drawn from among the firms constituting the total manufacturing sample analysed in the previous chapters. The goal of the analyses is to identify those financial ratios which are best able to discriminate among the selected industries and to examine how far these ratios do indeed reflect the underlying economic and structural characteristics of those industries. This will provide further evidence of the descriptive ability of accounting numbers. The results will be used to investigate the extent of homogeneity of the industries concerned and the degree of success of the Stock Exchange Industrial Classification (SEIC) system in forming economically meaningful groups of quoted firms. We shall also examine whether misclassifications, if any, from one industry to another are sufficiently systematic to enable us to form more homogeneous groups of industries.

The nature of the analysis conducted, reported in this chapter, is similar to that of the manufacturing and distribution sectors (hereafter, referred to as MFG - DIST analysis) presented in the

last chapter with the difference that, because of the larger number of groups involved, the number of discriminant functions is more than one. Extension of the two group analysis to more groups is briefly described in Appendix 7.1. Since the underlying assumptions are the same in both cases and have been discussed in the last chapter we shall not repeat them here.

8.1 Selection of Sample for Analysis

- 8.1.1 The sample consists of 264 firms for the years 1972 to 1976 and 251 for 1977. The firms were drawn from fourteen industries included in our manufacturing sample. Although our total manufacturing sample included several other industries, as shown in Appendix 5.1, they were excluded from the analysis reported here since the number of firms in each was too small (10 or fewer) for meaningful analysis. The smallest industry in our sample, Footwear, has eleven member firms. Table 8.1 shows the industry distribution of the sample over the 14 industries.

No	Industry	Ind. Code	Size (1972-76)	Size (1977)
1	Building Materials	(BLDG)	14	25
2	Metallurgy	(METL)	32	15
3	General Food Manufacturing	(FOOD)	49	21
4	Packaging and Paper	(PACK)	54	23
5	General Chemicals	(CHEM)	68	24
6	Electricals	(ELEC)	19	21
7	Industrial Plant	(INPL)	22	19
8	Machine and Other Tools	(MACH)	28	13
9	Light Electronics etc.	(LIEL)	35	15
10	Motor Components	(MOCO)	41	17
11	Clothing	(CLTH)	59	25
12	Wool	(WOOL)	61	14
13	Miscellaneous Textiles	(TEXT)	62	21
14	Footwear	(FOOT)	64	11
Total			264	251

Table 8.1: Industry Distribution of Sample

8.1. 2 The industries in our sample represent a wide spectrum of product characteristics, production technology, age etc. Some of them are engaged in processing activities while others are in engineering. Their products include consumer goods as well as producer goods. Given these differences, they may be expected, in the light of the arguments set forth in Chapter 2, to differ in terms of asset, liability and cost structures and, hence, in terms of their financial ratios.

8.2 14-industry Discriminant Analysis

8.2. 1 As in the case of the manufacturing and distribution samples, discriminant analysis of the 14 industries was carried out for each year from 1972 to 1977. The analysis was repeated using the Lachenbruch Holdout method. The relative discriminant power of the individual ratios was estimated using the approximate scaled-weighted method. The predictive power of the annual models and hence the stability over time of the mutually distinct characteristics of the industries were assessed by testing the models on the samples of subsequent years. Both linear and quadratic classification rules were utilised. The ratios constituting the annual models are shown in Table 8.2.¹

8.2. 2 Chisquare and F statistic tests are highly significant at almost 0.00 level. The null hypothesis of no difference among the means of the 14 industries can, therefore, be safely rejected. The relative discriminating power of the ratios was assessed by the scaled-weighted

1. There is generally a low degree of inter-correlation among the discriminant ratios. Out of 133 pairwise correlation coefficients among the discriminant ratios in the 6 models 112 were below 0.31, 9 between 0.32 and 0.40, 7 between 0.41 and 0.50 and only 5 between 0.51 and 0.70.

1972		1973		1974		1975		1976		1977	
Ratio	DP	Ratio	DP	Ratio	DP	Ratio	DP	Ratio	DP	Ratio	DP
Days Drs	27	$\frac{Dr}{Inv}$	22	Days Drs	22	$\frac{VA}{ATCE}$	19	$\frac{Dr}{CA}$	20	Days Drs	22
$\frac{Dr}{Inv}$	20	Days Drs	17	$\frac{VA}{ATCE}$	19	$\frac{TNI}{ATCE}$	17	$\frac{FF}{S}$	20	$\frac{Dr}{CA}$	19
$\frac{VA}{ATCE}$	13	$\frac{TA}{ER}$	16	$\frac{CF}{S}$	17	Days Drs	17	Days Drs	20	$\frac{ATNW}{S}$	13
$\frac{Dr}{Cr}$	11	$\frac{EBIT}{S}$	14	$\frac{S}{AINV}$	15	$\frac{Dr}{CA}$	15	$\frac{CL}{Cr}$	14	$\frac{VA}{ANCE}$	12
$\frac{FF}{S}$	10	$\frac{S}{AFA}$	12	$\frac{Dr}{Cr}$	12	$\frac{EBIT}{S}$	14	$\frac{PBT}{ATNW}$	11	$\frac{CL}{Cr}$	12
$\frac{QA-CL}{PDOE}$	10	$\frac{CL}{Cr}$	12	$\frac{NI}{ANW}$	10	$\frac{ACr}{COS}$	11	$\frac{VA}{ANCE}$	9	Sales	8
$\frac{FA}{TA}$	9	TNW	8	$\frac{CA}{TA}$	5	$\frac{S}{AFA}$	6	$\frac{S}{AFA}$	6	$\frac{CA}{TA}$	8
										TNI/S	6
	100		101		100		99		100		100
TNF	7		7		7		7		7		8
NSF	4		3		4		4		4		4
λ	.17		.18		.17		.18		.16		.16
χ^2	446.00		438.20		453.40		440.30		465.00		437.50
F	5.48		5.37		5.59		5.40		5.75		4.65
α	0.00		0.00		0.00		0.00		0.00		0.00

Note: λ = Wilk's Lambda; χ^2 = Chisquare statistic; F = F-statistic; α = the level of significance;

DP = Discriminating Power in percent, calculated using the scaled-weighted method. Total DP does not equal 100 because of rounding errors. TNF = Total number of discriminant functions and NSF = number of functions significant at 0.01. Degrees of Freedom for χ^2 test 91 (1972-76) and 104 (1977), for F test 91 and 1529.5 (1972-76) and 104 and 1594.8 (1977). On the different statistics and associated degrees of freedom see Appendix 7.1.

Table 8.2: Annual Discriminant Models and Their Discriminating Power

coefficient method ². The most consistent discriminator is Days Drs which appears in all the annual models explaining between 17% to 22% of the total discriminating power of the models. Although the other ratios are less consistent, in terms of the basic dimensions represented the models are quite stable. The dimensions are shown in Table 8.3 and their contributions to the total discriminating power of the models in Table 8.4. Although 8 dimensions are represented in one or more of the models Short Term Solvency and Size are the least stable appearing in only one model. Short Term Asset Intensity, though stable, is not very important accounting, on average, for less than 8% of the discriminating power. The other five dimensions contribute nearly 85% of that power. Profitability is represented consistently by profit margin ratios but in 1974 to 1976 additionally by return on capital ratios. For those years the contributions of the individual ratios have been treated as additive to provide a rough measure of the total contribution of the dimension.

8.2. 3 The most important dimension, Turnover, emphasises the difference among the manufacturing industries in the rates of utilisation of their assets. It may be recalled from Table 7.7 that this dimension also differentiated manufacturing from distribution firms. Another dimension which can discriminate not only between manufacturing and distribution firms but also among manufacturing firms is Labour Intensity. A major difference in the dimensional composition of the models is that Structural Liquidity did not figure very prominently in the MFG-DIST case whereas it is the second most important dimension in the present analysis. The economic meaning of the various dimensions as discriminators among manufacturing industries is investigated later in this chapter.

2. It may be recalled that in the MFG-DIST analysis (see paragraph 7.4.3) we compared the rankings by standardised discriminant coefficients and scaled weighted coefficients. In the present case since there are 7 or 8 discriminant functions, each set of discriminant coefficients will produce a different ranking. Therefore, the standardised coefficients method is not applicable. The low degree of collinearity among the ratios (see footnote 1 ante) indicates that the rankings by the scaled weighted coefficients method may be fairly reliable (see paragraph 6.1.1).

1972		1973		1974		1975		1976		1977	
Ratio	Dim	Ratio	Dim	Ratio	Dim	Ratio	Dim	Ratio	Dim	Ratio	Dim
Days Drs	TO	Dr/INV	SL	Days Drs	TO	VA/ATCE	LI	Dr/CA	SL	Days Drs	TO
Dr/INV	SL	Days Drs	TO	VA/ATCE	LI	TNI/ANCE	PFT	FF/S	PFT	Dr/CA	SL
VA/ATCE	LI	TA/ER	LI	CF/S	PFT	Days Drs	TO	Days Drs	TO	ATNW/S	TO
Dr/Cr	TCr	EBIT/S	PFT	S/AINV	SL	Dr/CA	SL	CL/Cr	TCr	VA/ANCE	LI
FF/S	PFT	S/AFA	STAI	Dr/Cr	TCr	EBIT/S	PFT	PBT/ATNW	PFT	CL/Cr	TCr
(QA-CL) PDOE	STS	CL/Cr	TCr	NI/ANW	PFT	ACr/COS	TCr	VA/ANCE	LI	SALES	SIZE
FA/TA	STAI	TNW	SIZE	CA/TA	STAI	S/AFA	STAI	S/AFA	STAI	CA/TA	STAI
										TNI/S	PFT

Table 8.3: Financial Dimensions Represented in the Annual Models

Note: Dim = Dimension. For key to other abbreviations see Table 8.4.

Dimension	Discriminating Power in Percent in					
	1972	1973	1974	1975	1976	1977
Turnover (TO)	27	17	22	17	20	35
Structural Liquidity (SL)	20	22	15	15	20	19
Labour Intensity (LI)	13	16	19	19	9	12
Profitability (PFT)	10	14	27	31	31	6
Trade Creditors (TCr)	11	12	12	11	14	12
Short Term Asset Intensity (STAI)	9	12	5	6	6	8
Short Term Solvency (STS)	10	-	-	-	-	-
Size	-	8	-	-	-	8
	100	101	100	99	100	100

Table 8.4: Relative Discriminating Power of the Dimensions

Note: 1) The totals do not equal 100 in some years because of rounding errors.

2) The difference in sample size in 1977 (see Table 8.1) may probably account for the slightly larger variations in the relative discriminatory powers of the dimensions compared to the other years.

8.2. 4 Validity of the Multivariate Normality Assumption: The necessary and sufficient conditions for multivariate normality were discussed in paragraphs 7.4.5 to 7.4.8. For the reasons set out there we may initially examine the univariate distributions of the discriminant ratios. Statistics on the distributions (Appendix 5.8) indicate that none of the ratios is strictly normally distributed³. We may, therefore, conclude that the assumption of multivariate normality is not tenable. The operational validity of the models may, however, be corroborated by the Lachenbruch holdout method and their "predictive" power.

3. This is based on the entire manufacturing sample. Investigation of the multivariate normality of the ratios within each of the 14 industries could not be carried out because of the small sample sizes involved.

8.3 Classificatory Power of the Discriminant Models

- 8.3. 1 The original sample was initially reclassified using linear classification functions. To study the extent of bias in the OS method classification was also performed under the LH method. The annual classification matrices under both methods are contained in Appendix 8.1. The overall classification results are presented in Table 8.5. The OS method reveals considerable bias compared to the Lachenbruch method. This may be contrasted with the results of the MFG - DIST analysis in which the two methods differed very little (see Table 7.8). The high degree of bias is probably due to the small sample size of the industries involved. Lachenbruch (1975, p. 33-36) suggests that in small samples the apparent error rate (i.e. the rate estimated by the OS method) will be highly biased and that in such cases the LH method is preferable. In terms of the unbiased correct classification estimate, the discriminant ratios have only modest discriminatory power. Once again the result is in striking contrast to that in the MFG - DIST case.

Year	Original Sample Method (%)	Lachenbruch Holdout Method (%)
1972	45.08	33.33
1973	43.18	32.20
1974	42.81	31.82
1975	41.67	31.82
1976	42.40	30.30
1977	41.04	25.90
Average	42.70	30.90

Table 8.5: Classificatory Power of the Discriminant Models (Linear Rule)

Note: These classifications are based on prior probabilities assumed equal to the sample proportions (see paragraph 7.3.4 and Table 8.1).

- 8.3. 2 The proportionate chance criterion for the 14 industry analysis using the sample proportions as prior probabilities is 7.40%⁴. Compared to this

4. See paragraph 7.5.4 on the calculation of the proportionate chance criterion in the two group case. This is extended to the 14 group case.

the lowest unbiased estimate of correct classification is 25.90% in the case of the 1977 model. The significance of the models' classification accuracy may be tested using the t-test ⁵.

$$t = \frac{25.90 - 7.40}{\sqrt{\frac{7.40 \times 92.6}{251}}} = 11.20 \text{ (degrees of freedom = 250)}$$

This value is significant at better than the 0.001 level. Thus the annual models are highly significant in their classificatory power although this is relatively modest. This confirms the statistically very high discriminatory power of the ratios shown earlier by the Chisquare and F tests.

8.3. 3 Test of Equality of Dispersion Matrices: In order to assess the appropriateness of using linear discriminant functions tests of equality of the dispersion matrices of the fourteen industries were undertaken. The calculated F statistics and the level of their significance are shown in Table 8.6. The null hypothesis of equality can be rejected in every case at almost 100% level of confidence. The appropriate rule of classification is, therefore, the quadratic rule.

Year	F- statistic	Degrees of Freedom	Level of Significance
1972	1.62	364 & 28463	0.0
1973	1.51	"	0.0
1974	1.67	"	0.0
1975	1.35	"	0.0
1976	1.55	"	0.0
1977	1.43	468 & 26398	0.0

Table 8.6: Tests of Equality of 14 Industry Dispersion Matrices

Note: For the computation of the test statistic see Eisenbeis & Avery (1972, Appendix 1B.)

5. See paragraph 7.5.4 on the computation of the t-statistic.

8.3. 4 Results of Quadratic Classification: As with the linear rule quadratic classification was carried out under both OS and LH methods. The classification matrices are given in Appendix 8.2. The overall correct classification rates achieved by the two methods are shown in Table 8.7.

Year	OS method	LH method
1972	57.57	29.17
1973	62.12	30.30
1974	63.16	29.17
1975	56.44	22.35
1976	62.12	25.00
1977	66.94	21.12
Average	61.39	26.17

Table 8.7: Classificatory Power of the Annual Models (Quadratic Rule) (%)

8.3. 5 The difference between the two methods is considerable indeed. The LH method yields more or less the same rates of correct classification as between the linear and quadratic rule except in 1975 when the difference is widest at about 9%. The quadratic results must, however, be regarded with some scepticism since "quadratic functions are much more sensitive to bias in the apparent rate presumably because of the greater number of parameters to be estimated" (Lachenbruch, 1975, p. 69). Lachenbruch quotes the results of a 5-group, 8-variate analysis using both linear and quadratic functions carried out by Michaelis. The quadratic functions performed better than the linear functions in terms of the apparent error rates. However, when compared to the classification rates from an independent sample the quadratic rule revealed more bias. This bias was greater when the sample size was 30 in each group than when it was increased to 100. The mean bias in the linear case fell from 0.035 to 0.007 and in the quadratic case from 0.114 to 0.034 (p. 69).

8.3. 6 The bias in the OS method using the quadratic rule would, therefore, appear to result from overfitting accentuated by the small group sizes in our sample (see Table 8.1). Lachenbruch opines that "in general, larger sample sizes are needed for good convergence to the optimal

correct classification rates for the quadratic function approach than for the linear function approach" (p. 69). Our quadratic results in the case of MFG - DIST analysis broadly confirm the importance of large samples since the bias in that case was little compared to the linear results and even compared to the Lachenbruch classification results.

- 8.3.7 Predictive Power of the Discriminant Models: The annual models were used to classify the samples of subsequent years to test the predictive power of the models and to examine the extent of stability of the inter-industry differences which the models represented. The overall rates of correct classification of the prediction samples using both linear and quadratic functions are presented in Table 8.8.
- 8.3.8 In general the classificatory ability of the linear function is nearly the same as that of the quadratic function with the exception of the 1975 model which displays a slightly larger difference. This close agreement between the two types of classificatory rules is in striking contrast to the considerable differences ranging from 12.5% in 1972 to 25.9% in 1977 between the two rules when the original samples were re-classified (see Tables 8.5 and 8.7). Moreover the quadratic models consistently outperformed the linear models. With the prediction sample, however, the difference is marginal. The relatively high rate of correct classification achieved by the linear and quadratic functions under the OS method must be attributed to bias in the light of the LH method and the prediction sample results, this bias being greater in the quadratic case because of overfitting.
- 8.3.9 It is not surprising that the results of the LH method and the prediction sample method are in close agreement since bias in both cases is to a large extent eliminated. The different rules of classification, however, have clearly demonstrated that the discriminant ratios have considerable discriminating power and also that inter-industry differences persist over time.
- 8.3.10 Classification within Industry Groups: We have so far examined the overall classificatory power of the discriminant ratios. To study group homogeneity, however, we need to look at the classification

within each industry. Since the OS method yielded biased results, the following analysis is based on the LH classification results. In Table 8.9 are shown the percentage of firms correctly classified within each industry.

Predicted Year	Base Year									
	1972		1973		1974		1975		1976	
	L	Q	L	Q	L	Q	L	Q	L	Q
1973	38.3	42.4								
1974	30.7	33.0	38.3	42.1						
1975	34.1	34.5	33.3	30.3	37.1	42.1				
1976	29.0	34.5	35.2	35.4	34.1	34.5	39.0	39.4		
1977	31.9	29.7	35.1	29.2	32.8	31.7	33.7	43.1	40.9	41.6
Average	32.8	34.8	35.5	34.3	34.7	36.1	36.4	41.3	40.9	41.6

Table 8.8: Predictive Power of the Discriminant Models (% of correct classification)

Note: L = Linear rule. Q = Quadratic rule. Individual matrices are not provided being broadly similar to those under the linear and quadratic LH method. See Appendices 8.1 and 8.2.

8.3. 11 It may be observed that the linear rule is more efficient and marginally more symmetric as between industries and more consistent across time. Some industries have a higher percentage of firms correctly classified than others. The percentage of correct classification within industry may be regarded as a measure of industry homogeneity. On the basis of the six year average correct classification by the linear rule the fourteen industries are ranked in Table 8.10. The most homogeneous industries are Food, Clothing and General Chemicals while the least distinct are Textiles, Footwear and Metallurgy.

8.4 Discriminant Ratios and the Economic Characteristics of the Industries

8.4. 1 Our analysis has demonstrated the ability of the ratios in our data set to distinguish among different manufacturing industries in a statistically significant manner. In addition to this discriminating power the ratios must also reflect the underlying economic characteristics of those industries if they are to be adjudged as possessing descriptive ability as defined by us. The economic meaning of the ratios may be

Industry	Sample Size (1972-6)	1972		1973		1974		1975		1976		1977	
		Q	L	Q	L	Q	L	Q	L	Q	L	Q	L
BLDG	25	36	32	28	24	24	44	20	44	28	12	25	21
METL	15	7	7	7	7	13	7	13	13	0	0	8	0
FOOD	21	43	57	52	57	52	57	57	67	48	57	30	55
PACK	23	13	26	35	26	30	30	17	30	17	35	19	24
CHEM	24	25	54	38	42	29	46	33	33	33	38	29	33
ELEC	21	19	38	24	29	29	19	14	53	10	38	17	17
INPL	19	42	32	21	37	26	37	5	21	11	21	17	39
MACH	13	15	23	8	15	23	39	15	38	15	0	7	7
LIEL	15	40	33	7	27	20	0	13	13	20	53	0	7
MOCO	17	47	18	41	35	35	18	24	6	35	12	38	25
CLTH	25	32	44	52	56	40	56	48	56	48	52	38	46
WOOL	14	7	7	29	43	29	29	21	29	36	43	29	29
TEXT	21	48	29	33	19	29	19	5	5	19	24	15	15
FOOT	11	18	46	18	9	9	9	0	0	9	18	0	18
	264	29	33	30	32	29	32	22	32	25	30	21	26

Table 8.9: Rates of Correct Classification Within Industries (LH Method)
(%)

Note: The figures have been rounded to the nearest integer. For key to the industries and 1977 sample size see Table 8.1.

Q = Quadratic rule; L = Linear rule.

analysed with reference to the industry means on the discriminators. The means of those ratios which appeared consistently in our discriminant models are shown in Appendix 8.3. Although the basic dimensions represented in all the models number only seven (see Table 8.4) some of them are represented by more than one ratio in the Appendix because of the additional insight they provide.

- 8.4. 2 All the ratios other than Days Drs and Dr/CA in the fitted models have been transformed (see Appendix 5.9) but they can still be used to indicate the relative position of the industries. All the ratios are statistically significant as univariate discriminators among the industries at at least 0.05 level as indicated by the relative F-statistics. On the basis of mean ratio values considered separately

the industries, however, appear not too removed from one another except on Days Drs, Dr/CA and Dr/INV. This perhaps helps to explain the low discriminating power of the models. In Table 8.11 the industries are ranked on the basis of their mean values on each dimension represented by one or more ratios. The discriminant ratios may be deemed meaningful if the relative ranking of the different industries is more or less consistent with the underlying economic attributes of those industries.

Industry	6 year Average Correct Classification (%)
Food	58.4
Clothing	51.6
General Chemicals	41.0
Electricals	32.2
Industrial Plant	31.0
Wool	29.8
Building Materials	29.5
Packaging and Paper	28.6
Light Electronics	22.3
Machine Tools	20.4
Motor Components	18.9
Textiles	18.4
Footwear	16.7
Metallurgy	5.6

Table 8.10: Homogeneity of Manufacturing Industries

8.4. 3 Turnover represented by Days Drs, the amount of investment in debtors is largely determined by factors such as

- 1) the unit value of the product
- 2) its durability
- 3) growth phase of industry and
- 4) trade custom.

Product life and high unit value are important considerations in industries producing consumer durables or plant and equipment. The benefits from these goods will be realised by the user over a long period of time. Such industries may, therefore, be expected to extend

credit, thereby increasing their investment in debtors much more than industries which sell products of comparatively low value and short duration e.g. clothing, footwear and food. The ranking of industries on Days Drs broadly confirms this a priori expectation since the four highest ranking industries are Machine Tools, Industrial Plant, Electricals and Light Electronics all of which produce high cost, long life products. At the lower end are Wool, Clothing, Food and Footwear selling low value, low durability products.

No.	Turnover Days Drs	Structural Liquidity		Trade Creditors Cr/CL ¹	Labour Intensity ER/TA ¹	Short Term Asset Intensity S/AFA	Profitability	
		Dr/CA	Dr/INV				FF/S	CF/S
1	MACH	BLDG	BLDG	MOCO	CLTH	FOOT	LIEL	CHEM
2	INPL	METL	CHEM	INPL	FOOT	INPL	ELEC	PACK
3	ELEC	CHEM	PACK	PACK	MOCO	CLTH	BLDG	LIEL
4	LIEL	PACK	INPL	BLDG	INPL	LIEL	CHEM	MACH
5	CHEM	FOOD	METL	METL	ELEC	METL	MACH	ELEC
6	BLDG	LIEL	FOOD	ELEC	MACH	FOOD	MOCO	BLDG
7	METL	MOCO	LIEL	CHEM	TEXT	TEXT	METL	MOCO
8	MOCO	INPL	ELEC	LIEL	WOOL	MACH	PACK	WOOL
9	PACK	ELEC	MOCO	TEXT	PACK	WOOL	CLTH	TEXT
10	TEXT	MACH	MACH	CLTH	LIEL	ELEC	INPL	METL
11	WOOL	TEXT	TEXT	MACH	BLDG	MOCO	WOOL	INPL
12	CLTH	CLTH	CLTH	FOOD	FOOD	BLDG	TEXT	CLTH
13	FOOD	FOOT	WOOL	FOOT	METL	CHEM	FOOT	FOOD
14	FOOT	WOOL	FOOT	WOOL	CHEM	PACK	FOOD	FOOT

Table 8.11: Ranking of 14 Industries on the Discriminant Dimensions

Note: For key to the industries see Table 8.1. 1 = Reciprocal of original ratio (see Appendix 5.9).

- 8.4. 4 An important factor determining investment in debtors is the growth phase of the industry concerned. Fast growing industries characterised by innovations may extend trade credit as a means of increasing the acceptability of their products to the consumers. After analysing the net trade credit (i.e. debtors less creditors) behaviour of companies during the period 1949-53, Henderson (1959) concluded:

"In general, it seems to be clear that growth involved granting additional net trade credit during the period. It was among the rather static companies that trade credit was often a net source of funds. "Industrial" reasons predominated in determining the pattern of trade credit. Some fast-growing companies may have used the offer of exceptionally liberal trade credit terms as one method of increasing their share of the market" (p. 101).

- 8.4. 5 Henderson's observations about companies may easily be extended to fast-growing and slow-growing industries. The top ranking industries in our sample e.g. Electricals, Light Electronics and Chemicals are marked by a high degree of product and process innovation and are among the fastest growing industries in the U.K. On the other hand, the lowest ranking industries, Footwear, Food, Clothing, Wool and Textiles are mature or declining industries where the scope for growth is severely limited.

"In the chemical industries the number of new products which can be developed and produced is infinite. The applications of the science of electronics...do not appear to be reaching their limits. In the other and older manufacturing industries the scope for such applications is limited" (Hays, 1972, p. 92; see also Central Office of Information, 1977, p. 13).

- 8.4. 6 The role of custom in the determination of trade credit was noted in Chapter 2, Section 2.6. However, it is secondary and derivative. The primary factors are product and demand related which help to raise the structure of trade custom. However, once developed trade custom tends to be independent and self-reinforcing. This perhaps explains the consistency of Days Drs as the most powerful discriminator in our models.
- 8.4. 7 The second most important discriminator, Structural Liquidity, measures the relative importance of debtors and inventory in the structure of current assets. We have already noted the industry determined nature of the debtors level. Level of investment in inventory is influenced by such factors as:

- 1) product life
- 2) the production process
- 3) cost of holding inventories
- 4) diversity of product range of the industries
- 5) access to raw materials and
- 6) the relative bargaining power of buyers and sellers of the products.

Industries with products of short life may be expected to hold smaller inventories than industries like Motor Components, Electricals, Light Electronics etc. whose products do not deteriorate with time. Where production is by continuous and highly automated processes it is likely to be faced with less uncertainty due to strikes etc. Consequently, the need for high inventory holdings will be less in process type industries (e.g. Metallurgy, Chemicals, Packaging, Food) than in industries whose production process involves labour-dependent assembling, engineering etc. (e.g. Motor Components, Industrial Plant).

- 8.4. 8 The cost of financing inventories is a major determinant of the level of inventories. High unit value, physical size and the need for special storage facilities a priori would be expected to lead to lower levels of inventory. On the other hand, diversity of products sold will likely mean larger inventories. Motor Components and Machine Tools cover a wide diversity of goods. In such industries the high cost of holding inventories arising from high unit value or physical size and the need to maintain minimum levels of a diversified range of products will act in conflicting directions. In certain industries like Motor Components firms are expected to hold reasonable levels of stock which the motor manufacturers themselves are loathe to hold because of the cost of financing that stock. In this industry the component manufacturers are weak in their bargaining power relative to the users, the motor manufacturers. Silberston (1958, p. 32) noted that most motor manufacturers

"try to safeguard themselves against minor disturbances by making their suppliers carry a stock of finished parts for them. Vehicle manufacturers engaged on flow production are extremely reluctant to hold any more stocks themselves than they can possibly help. Usually they have on hand sufficient stocks for only a few days' production and rely on frequent deliveries from suppliers"

Motor Component manufacturers also cater to the replacement market with uncertain demand patterns which would require them to hold large stocks.

8.4. 9 Textiles, Clothing, Footwear and Wool which figure at the bottom of the league in terms of Structural Liquidity are relatively declining industries. We have seen how a low level of investment in debtors often goes with the lack of growth prospects. Additionally, these industries have highly cyclical and seasonal demand patterns which lead to uncertainty in demand and less efficient inventory holding resulting in a higher level of inventory relative to debtors. Although manufacturers in these industries could shift their inventory to wholesalers and retailers thus converting it into debtors they lack the financial strength to do so because of their weak bargaining power. Moreover, the supply of raw materials to these industries, say, wool or cotton is seasonal and the production processes more labour intensive causing firms to hold higher levels of both raw materials and finished products ⁶.

8.4. 10 The relative positions of the manufacturing industries on Structural Liquidity are, therefore, clearly traceable to their underlying economic characteristics. The ranking on Trade Creditors provides further evidence of this relationship. Textiles, Clothing, Food, Footwear and Wool are among the smallest users of trade creditors as a source of finance. These industries were also seen earlier as extending the least trade credit. Thus trade creditors tend to match trade debtors. However, these industries also carry relatively higher stock which cannot possibly be financed by trade creditors. An alternative source of finance for inventories is bank overdrafts and loans. That these industries closely match their debtors and creditors is evidenced by the ratio Dr/Cr in Appendix 8.3. They have smaller mean values than the other industries, in general.

8.4. 11 The other industries rely more on trade creditors but also provide more net credit. Since they are relatively fast growing industries their need to finance larger trade debtors is much greater. While they rely on trade creditors for part of this additional finance required they

6. See "Textiles, Industrial Review to 1977", of the National Economic Development Office, May 1974 on the growth and cyclical nature of the textiles and clothing industries.

appear to rely also on long and medium debt or equity to finance not only their capital investments but also inventory and trade debtors. These industries appear to make use of all possible sources to finance their growth. Their growth prospects unlike those of declining industries like Clothing and Footwear would, of course, facilitate raising long term capital in the capital markets. For companies, Henderson (1959) observed that during the period 1949-53 "a larger proportion of companies granting a lot more trade credit than of all companies did make new (capital) issues... - 38% as compared with 32% for all companies" (p.106) ⁷.

8.4.12 Labour Intensity and Value Added: This is the third most important discriminant dimension. Here the process type industries Building Materials, Food, Metallurgy and Chemicals are the lowest ranked signifying their relatively greater capital intensity. For example "the chemical industry is, in general, highly capital intensive. Large modern plants make extensive use of automation....Considered on an industry basis, the level of employment has been constant within narrow limits over the decade" ⁸. At the other end of the scale with very low capital intensity are Clothing and Footwear. In clothing "although production has been mechanised to a large extent, the industry remains labour intensive, skilled, individual work being required at various stages of garment manufacture" ⁹. "Making clothing is largely an assembly operation and the parts do not lend easily to other than human manipulation"¹⁰.

8.4.13 The relative levels of capital intensity in the various industries may be understood from Table 8.12 which shows the capital expenditure per head in 1973 by the industries concerned. The industries have been classified using the Standard Industrial Classification (SIC) 1968 and not the Stock Exchange Industrial Classification (SEIC). Thus they

7. No information regarding the statistical significance of this difference is available.

8. Central Office of Information (1978), p. 16.

9. -do- (1977), p. 17.

10. Quoted from Financial Times of April 16th 1980 based on "The 1980's: The Decade for Technology? A Study of the state of the art of Assembly of Apparel products prepared for the EEC Commission".

are not strictly coterminous with those in our sample albeit that they bear similar names. Nevertheless the table provides a reasonable indication of the relative capital expenditure levels.

"The annual capital expenditure gives an indication of the relative capital intensity of the different industries. It is generally true to say that those industries which are already capital intensive tend to spend more per employee on new capital expenditure than those industries which are labour intensive" (Wood, 1975, p. 21).

The SEIC industries are listed in Table 8.11 in decreasing order of Labour Intensity (i.e. increasing capital intensity) and the ranking of these industries is nearly the same as that of the SIC industries on capital intensity in Table 8.12. Thus the third most significant discriminator in our models reflects reasonably well the underlying labour to capital structure of the industries in our sample¹¹.

8.4. 14 Structure of Assets: Short Term Asset Intensity measures the relative intensity of fixed and current assets. The turnover ratio S/AFA representing this dimension will be influenced by both the underlying capital intensity of the industry and the factors affecting the turnover such as demand patterns, product life etc. which were discussed in paragraphs 8.4.3 to 8.4.9. Gupta and Heufner (1972) identified the following industry characteristics as affecting fixed asset turnover:

- 1) nature of the production process
- 2) fixed asset composition and
- 3) plant size and level of mechanisation.

Primary processing industries often have longer production times and make greater use of complex machinery e.g. Chemicals, Building Materials. Some industries which process natural products like timber or pulp often hold natural resources like forests which add to the fixed asset base and thus reduce the turnover. Packaging and Paper in our sample which has the lowest fixed asset turnover is an example.

11. Our results after allowing for the problems of comparison between SEIC and SIC industries are consistent with the statistics of net output per head in some SIC Order industries in 1972 e.g. (in decreasing order) Chemicals and Allied Industries (£5147), Food, Drink and Tobacco (£3848), Mechanical Engineering (£2785), Electrical Engineering (£2732), Metal Manufacture (£2680) and Textiles (£2242). See Gower Economic Publications (1974) Figure A. 18.

SEIC Industry in our sample	Corresponding SIC Order	Industry	Capital Expenditure per head (£) in SIC industry
Clothing } Footwear }	XV	Clothing & Footwear	85
Electricals } Light Electronics }	IX	Electrical Engineering	185
Industrial Plant } Machine Tools }	VII	Mechanical Engineering	217
Textiles } Wool }	XIII	Textiles	331
Packaging & Paper	XVIII	Paper, Printing & Publishing	275
Building Materials	XVI	Bricks, Pottery, Glass etc.	487
Food	III	Food, Drinks & Tobacco	479
Metallurgy	VI	Metal Manufacture	602
Chemicals	V	Chemicals & allied industries	616

Table 8.12: Capital Expenditure by Industries in 1973 ¹².

Note: Motor Components has been excluded since it could not be identified with any SIC Order industry. On the differences between SEIC and SIC see Section 2.2.

8.4.15 On the other hand, "in industries where style and fashion are important and where customer tastes and preferences change rapidly, large scale mechanisation is difficult" (Gupta, et al, 1972, p. 86). As we have seen earlier Clothing and Footwear are the least capital intensive because the discontinuous production process in these industries precludes the use of large scale machinery. Their ranks in Table 8.11 as the first and third highest fixed asset turnover industries are a consequence of the nature of their production process and technology. Although Food is highly capital intensive it ranks sixth on fixed asset turnover because of the very high sales volume of that industry ¹³. While

12. Compiled from Wood (1975).

13. In terms of gross output the Food, Drink and Tobacco industry had an output valued at almost twice that of any other manufacturing industry and accounted for 19.4% of output of all manufacturing industries (Gower Economic Publications, 1974, p. 4).

Short Term Asset Intensity explains the relative position of industries' it must be remembered that it was the least significant of the six dimensions considered (see Table 8.4). As a result we are able to account for only those industries lying at the extremes of the spectrum.

8.4.16 The last dimension to be considered, Profitability, is represented by the Funds Flow (FF) and Cash Flow (CF) to Sales ratios. The highest ranking industries Light Electronics, Chemicals, Electricals are some of the fastest growing industries (see paragraph 8.4.5) whereas the lowest ranking ones Clothing, Textiles and Footwear are relatively stagnant. One of the reasons for the difference in the rankings is the difference in the growth rates of these industries. The very low rank of Food is probably due to the small unit value of the products as much as to the fact that it is a mature industry where profit margins tend to be under pressure ¹⁴. Rankings on CF/S are slightly different from that on FF/S. This is possibly due to the differential cost structures among the industries. For example Chemicals and Packaging and Paper with high capital investments are likely to have higher depreciation charges, as well as higher retentions. This is perhaps one of the reasons for their rankings to be higher on CF/S than on FF/S ¹⁵.

8.5 Analysis of Misclassifications

8.5.1 The classificatory power of the discriminant ratios, though statistically significant, was found to be modest. The industry means on the discriminant ratios also indicated that distinction between some industry

14. Although profit margins may be low in Food and related industries since sales volume is very high (see footnote 9) absolute profits may be high (Gower Economic Publications, 1974, p. 14).

15. Of the two ratios CF/S has a greater discriminatory power than FF/S. The univariate F ratio for CF/S was 4.89 and for FF/S 2.97 (see Appendix 8.3). CF/S is affected to a larger extent than FF/S by the characteristics of an industry such as capital intensity, growth opportunities which influence the level of retentions etc. (see paragraphs 2.3.3., 2.3.4., and 2.4.11). The greater discriminatory power of CF/S is, therefore, quite plausible.

groups could not be clearly drawn. However, the rankings on the ratios indicated a certain pattern of grouping of industries. For example, on Days Drs and Dr/CA the following groups were evident:

- 1) Machine Tools, Industrial Plant, Light Electronics and Motor Components
- 2) Building Materials, Chemicals and Packaging and Paper
- 3) Food and
- 4) Textiles, Clothing, Wool and Footwear.

This clustering, however, is less strong on the other discriminators.

8.5. 2 A visual appreciation of the proximity of the different industry groups may be obtained from Figure 8.1 which plots the centroids of the 14 industries in the space of the first two discriminant functions for the year 1975^{16,17}. These two functions accounted for nearly 82% of the total discriminating power of the model (i.e. 82% of the trace). The stars on the plot represent the industry centroids. A much clearer picture is seen on the terrestrial map of the same discriminant space in Figure 8.2. Food (7) stands apart from all the other groups. This was already foreshadowed by the fact that it was the most homogeneous industry in terms of classification results (see Table 8.10). It is closer to the cluster of four industries: Building Materials (1), Metallurgy (4), Packaging and Paper (8) and General Chemicals (C) than to the other industries. A second cluster on the left of the map consists of five industries - Electricals (2), Industrial Plant (3), Motor Components (6), Light Electronics (5) and Machine Tools (D). This cluster is quite distinct from the third cluster in the upper half of the map, made up of Clothing (9), Wool (O), Textiles (A) and Footwear (B). The clusters are circled for convenient visual inspection.

8.5. 3 Further evidence of the aggregation of the basic industries into four clusters can be gathered from an examination of the pattern of

16. As already seen the classificatory and discriminating power of the models for the six years were broadly similar. The discriminant plots were also similar. Hence only the 1975 plot and map are shown here. They are derived from a linear model reclassification of the original sample.

17. Key to numbers and letters is provided on the plot and map.

PLOT OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). ⊙ INDICATES A GROUP CENTROID.

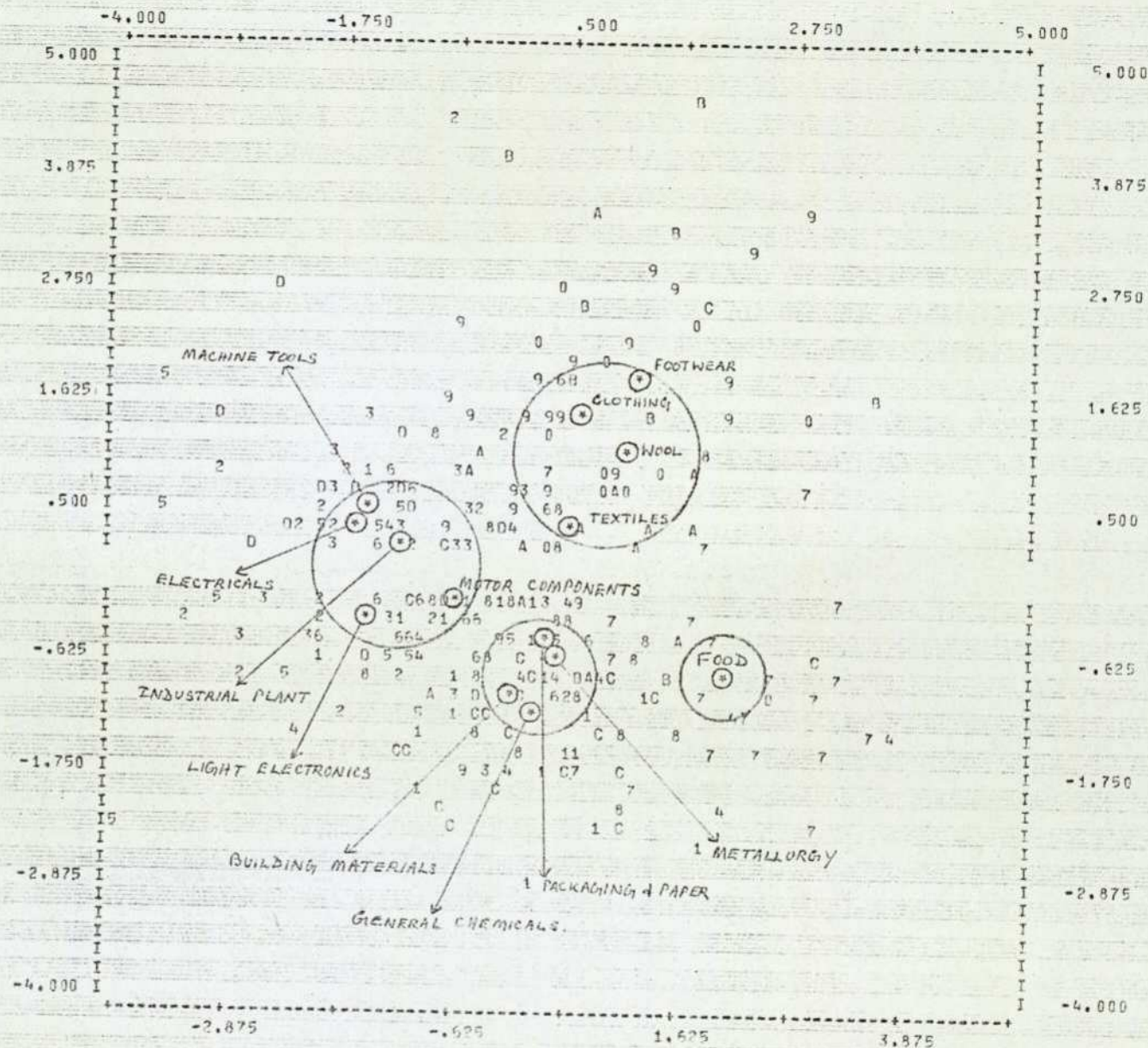


Figure 8.1: 14-industry Centroids in 2 Discriminant Function Space

TERRITORIAL MAP OF DISCRIMINANT SCORE 1 (HORIZONTAL) VS. DISCRIMINANT SCORE 2 (VERTICAL). * INDICATES A GROUP CENTROID.

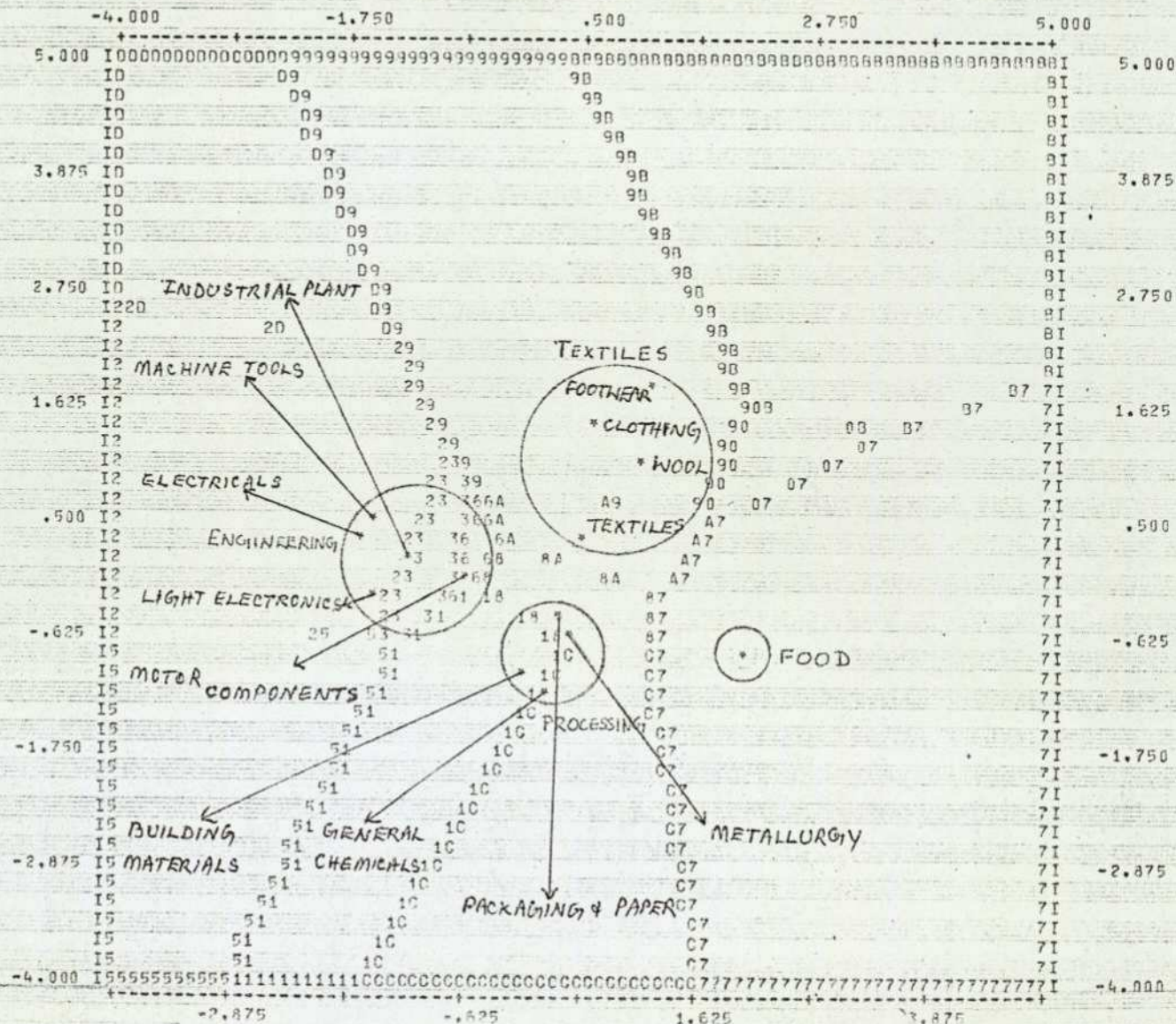


Figure 8.2: Territorial Map of 14-industry Discriminant Analysis

misclassifications in the classification matrices. In the classification matrices derived from the LH method using the linear and quadratic rules (see Appendix 8.1 and 8.2) the industries which cluster together are "boxed in"¹⁸. Food, though distinct, is also put into the box containing its nearest cluster noted above. The misclassification patterns clearly establish that the misclassifications have occurred within the clusters. Indeed, they indicate that although Food is highly distinguished, firms in the other four industries in the first cluster are often misclassified into Food. The misclassification patterns suggest that aggregation of industries into three or four clusters would yield groups which are more homogeneous within and well differentiated between. The empirical aggregation of the basic industries into super-industries and investigation of the latter's homogeneity are taken up in the next chapter.

8.6 Summary and Conclusions

- 8.6. 1 A sample of manufacturing firms drawn from 14 diverse industries was analysed with a view to identifying the financial ratios which would best discriminate among them. The discriminant models composed of the ratios identified by stepwise analysis were statistically significant. Similarly the classificatory power of both linear and quadratic models was also statistically significant but modest when allowance is made for the bias in the original sample method.
- 8.6. 2 Six basic dimensions were found to be represented consistently in the six discriminant models. In the order of their contribution to the total discriminating power of the models they were:
 - 1) Turnover
 - 2) Structural Liquidity
 - 3) Labour Intensity
 - 4) Profitability
 - 5) Trade Creditors and
 - 6) Short Term Asset Intensity

18. The classification matrices relate to 1975 for the reasons stated in footnote 16 above. Only Lachenbruch Holdout method results are discussed because they are the least biased as noted in paragraph 8.3.9 (see also Tables 8.5, 8.7 and 8.8).

The dimensions and the ratios representing them were seen as reflecting the differences in the substantive economic attributes of the industries. This was demonstrated by reference to the structure and operating characteristics of those industries. Moreover, the annual models also exhibited no substantial decline in their discriminatory power over time, indicating the persistence of inter-industry differences at least in the short run (see paragraph 8.3.7 to 8.3.9). Our hypothesis is that industry groups are stable over time (see paragraph 1.3.1), is, therefore, clearly acceptable.

8.6. 3 The analysis has clearly evidenced the descriptive ability of accounting numbers satisfying the operational criterion laid down in Chapter 3 that it will be a demonstration of the descriptive ability of financial ratios if the ratios constituting a discriminant model that has statistically significant power to discriminate among industries are economically meaningful (paragraph 3.5.16). However, the modest ability of the models to classify firms on the basis of the financial ratios indicates that

- 1) the ratios in our data set are not quite strongly descriptive or
- 2) the industries are not truly distinct in their substantive economic attributes although their end-products may be different.

8.6. 4 We reject the first explanation as inadequate given the evidence so far from both the manufacturing - distribution (MFG - DIST) analysis and the 14 industry analysis. In the case of the MFG - DIST analysis the discriminant models exhibited very high discriminatory power (see Section 7.5). Our analysis of misclassifications also indicated that there was probably substantial backward and forward integration in certain segments of the two sectors thereby blurring the distinction between them (see Section 7.7). Our financial ratios were found to be able to reflect the underlying structural characteristics of those segments. In the case of the 14 industry analysis presented in this chapter the descriptive ability of the models was seen to be statistically quite significant. There was also prima facie evidence of a systematic pattern of misclassifications among what appear to be technologically and operationally similar industries. The unspectacular discriminatory power of the models may probably be due to such similarity among the industries analysed.

8.6. 5 It would, therefore, seem that the second explanation is more plausible and needs further scrutiny. From our misclassification analysis there appear to be four clusters of the basic industries. These four "super-industries" might well be more homogeneous than the basic industries. These questions and the reasons for homogeneity at a higher level of aggregation are investigated in the next chapter.

Chapter 9

Search for Homogeneous Groups: Aggregation of Industries

9.0 Introduction

The four empirical industrial groups suggested by the analysis in the last chapter form the basis of the analysis presented here. Initially, the four groups were formed by pooling the firms in the constituent basic industries. A discriminant analysis of the four super-industries was carried out and the misclassifications analysed to examine the extent of homogeneity of those industrial groups. As the misclassification pattern indicated that Food was less homogeneous than the other three groups and that there was substantial misclassification of Food firms into Processing a three group discriminant analysis among Processing, Engineering and Textiles was undertaken. The results are presented and the reasons for the enhanced homogeneity of the three super-industries are investigated. Four- and three-group analyses reported here are similar in methodology to those in connection with the manufacturing vs distribution samples and the 14 manufacturing industries. The purpose of the analysis presented in this chapter is twofold:

- 1) to examine whether the empirical aggregation yields more homogeneous groups and
- 2) to examine whether the resulting homogeneity, if any, arises from similarities in the fundamental economic and structural characteristics of the basic industries. Evidence of enhanced homogeneity arising from such similarities is consistent with the descriptive ability of financial ratios as defined for the purpose of this study.

9.1 Four Group Discriminant Analysis

- 9.1.1 The purpose of the four-group analysis was to examine the degree of homogeneity of the groups. Given the fairly stable pattern of misclassifications in the 14-industry analysis it was considered sufficient to analyse just one year's sample. Accordingly, we report the results of our analysis of the 1972 sample of 264 firms the individual group sizes being as shown in Table 9.1.

No	Super-industry	Sample Size
1	Processing (Prs)	87
2	Engineering (Engg)	85
3	Textiles (Text)	71
4	Food (Food)	21
		264

Table 9.1: 4 Super-industry Distribution of Sample

9.1. 2 Stepwise discriminant analysis of the four groups resulted in a 5 ratio model as shown in Table 9.2.

Ratio	Dimension	Discriminating Power ^a (%)
1 Days Drs	Turnover	41
2 Dr/INV	Structural Liquidity	32
3 VA/ANCE	Labour Intensity	16
4 FF/S	Profitability	7
5 Sales	Size	4
		100

Table 9.2: 4 Super-industry Discriminant Model and its Discriminating Power

Note: Wilk's Lambda = 0.34. a - based on the scaled-weighted method.
(See Appendix 7.1.)

Chisquare = 279.68 with 15 degrees of freedom significant at 0.00 level. F-statistic = 22.51 with 15 and 707.1 degrees of freedom at 0.00 level.

The number of functions extracted was three of which the last was not significant at any reasonable level of significance. The overall discriminant model was highly significant. The null hypothesis of no difference among the four super-industries could be confidently rejected.

9.1. 3 Four ratios accounted for 96% of the discriminating power of the models. All the five ratios had also appeared in one or more of the annual discriminant models derived in the 14 industry case (see Table 8.2).

and the differences among the super-industries are defined along the same basic dimensions as were important in the latter context. Short Term Asset Intensity and Trade Creditors, however, appear not to be important in differentiating among the super-industries. The high discriminating power of the ratios is also accompanied by high classificatory power. The classification results using the OS and LH methods and both linear and quadratic rules are presented in Table 9.3. Quadratic rule classification was carried out since the dispersion matrices were unequal ¹. The overall classification rates are quite significant compared to the proportionate chance criterion of 0.29 ².

Classifi- cation Rule	Actual Group	No.	Predicted Group									
			OS Method					LH Method				
			Prcls	Engg	Text	Food	Over- all	Prcls	Engg	Text	Food	Over- all
Linear	Prcls	87	70	21	6	3	71	68	23	6	3	69
	Engg	85	19	73	7	1		21	71	7	1	
	Text	71	14	9	78	0		14	9	78	0	
	Food	21	33	10	14	43		33	10	14	43	
Quad- ratic	Prcls	87	67	24	6	3	72	63	25	6	6	67
	Engg	85	14	77	8	1		19	69	9	2	
	Text	71	9	9	83	0		9	11	78	3	
	Food	21	33	9	14	43		33	14	14	38	

Table 9.3: 4 Super-industries Classification Matrices (in percent)

Note: Figures have been rounded to the nearest integer.

- 9.1. 4 The results indicate that the classification patterns are fairly stable across the four methods. The stability was observed in the MFG-DIST case (see Section 7.5) but not in the case of the 14 industry analysis (see Section 8.3). It would appear that it is a function of both the number of groups and the sample size of each group - the fewer the groups

1. The F-statistic for test of equality of dispersion matrices was 2.66 with 45 and 21984 degrees of freedom and statistically significant at 9.8×10^{-7} level.
2. Calculated t value using the formula given in paragraph 7.5.4 is 15.05. This value is significant at better than the 0.005 level.

and larger the sample size, the more stable the results from different classification methods.

- 9.1. 5 More relevantly, the super-industries, Processing, Engineering and Textiles appear homogeneous whereas Food is much less so. One third of the Food firms are classified into Processing under all the four methods of classification. This may confirm the affinity between Food and Processing types of firms which was suspected from the misclassification patterns of the 14 industry analysis. A visual picture of the location of the four super-industries in the space of the first two discriminant functions is provided in Figures 9.1 and 9.2 which show the proximity of Food and Processing compared to the other two groups. Food manufacturing is in many ways similar to other types of processing like metallurgy or paper manufacture. All these industries process primary materials such as minerals or agricultural products into consumer or intermediate goods. It is, therefore, not surprising that Food bears a close resemblance to the other process type industries in its financial profile.
- 9.1. 6 Despite this process-related similarity between Food and other processing industries, Food still appears to have a significant identity of its own as shown by the fact that nearly 40% of firms in that industry are correctly classified. A possible reason for this may be the larger degree of vertical integration into distribution among the different Food industry segments. It may be recalled from our analysis of the differences between manufacturing and distribution enterprises that the largest number of misclassifications occurred in Food and related industries whereas there was a negligible number in Metallurgy and General Chemicals and none at all in Building Materials and Packaging and Paper (see paragraphs 7.7.3 and 7.7.6). Indeed Food is the only industry among the 14 to display substantial vertical integration. It might be plausible to suggest that the nine companies correctly classified into Food were able to retain their separate identity from the Processing group thanks to their non-manufacturing activities.
- 9.1. 7 To test this hypothesis the correctly classified firms were identified and checked against the list of misclassified manufacturing firms in

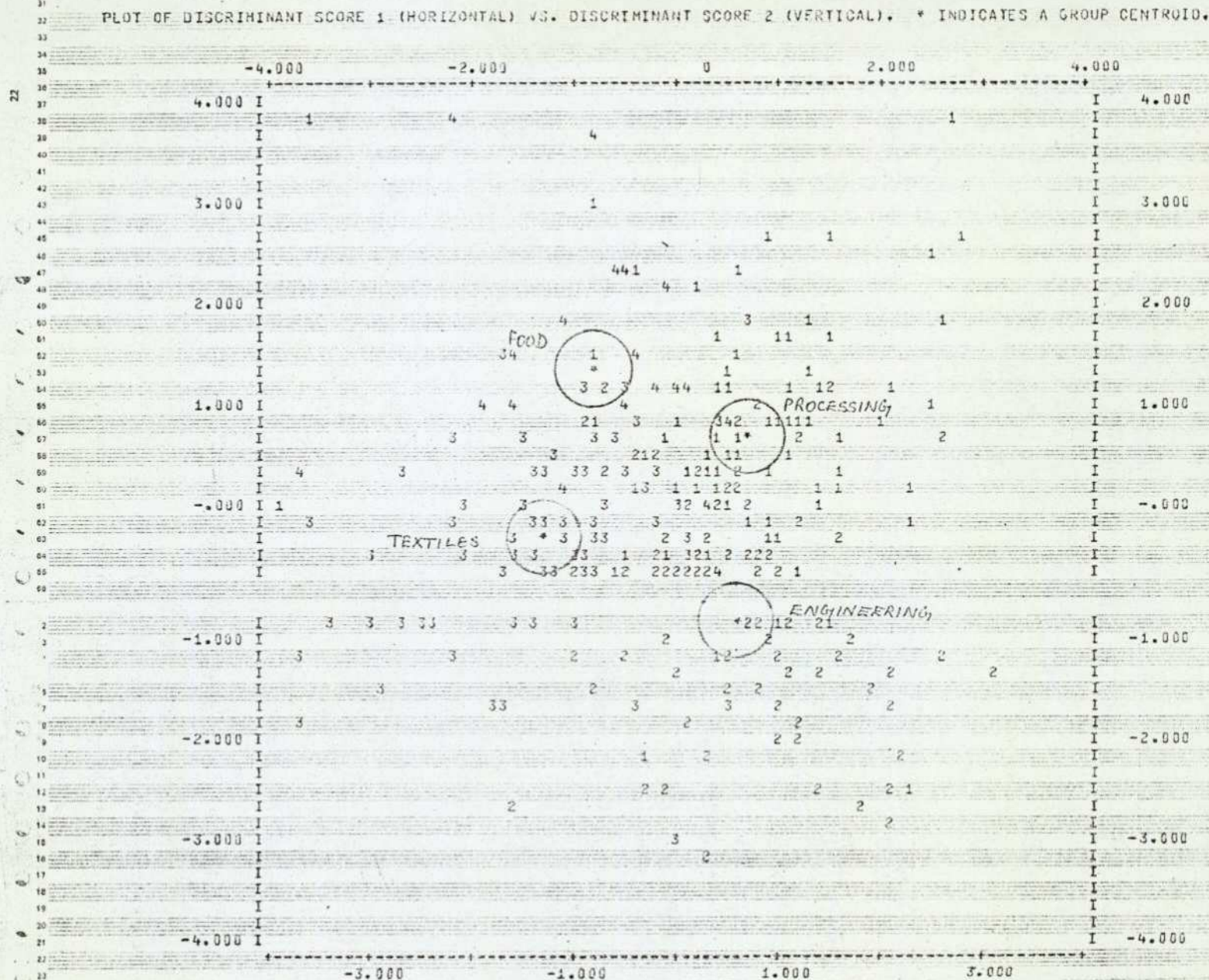


Figure 9.1 : 4 Super-industry Centroids in 2 Discriminant Function Space

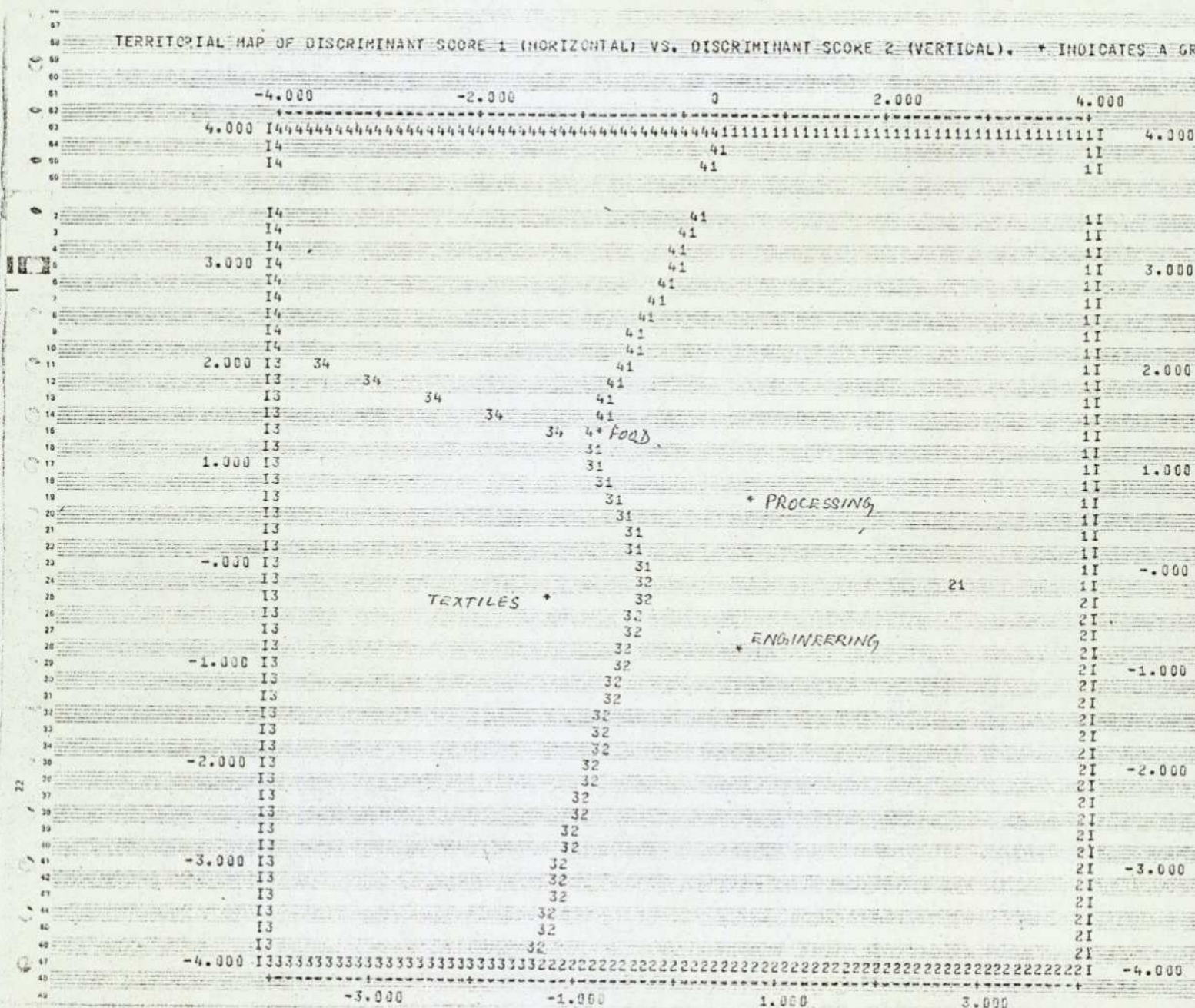


Figure 9.2: Territorial Map of 4 Super-industry Discriminant Analysis

Appendix 7.3. The following seven firms were correctly assigned to Food in the four group analysis but were among the nine misclassified as distribution firms in the MFG-DIST analysis.

- 1) Basset (Geo.) Hldgs
- 2) Bibby (J) & Sons
- 3) Highgate & Job Group
- 4) Lyons (J) & Co.
- 5) Pauls & Whites
- 6) Tate & Lyle
- 7) Unilever

9.1. 8 Our surmise then that the apparent separation of Food from the Processing group might be the result of a high degree of vertical integration in the Food industry receives prima facie support from the above analysis. There would thus appear to be a case for treating Food as part of Processing.

9.2 Discriminant Analysis of 3 Super-industries

9.2. 1 Pooling of the firms in the basic industries resulted in 3 super-industries with sample size distribution provided in Table 9.4.

No.	Super-industry	Size in	
		(1972-76)	1977
1	Processing (PrCs)	108	102
2	Engineering (Engg)	85	80
3	Textiles (Text)	71	69
	Total Sample Size	264	251

Table 9.4: Sample Size of Super-industries

9.2. 2 Stepwise discriminant analysis of the three groups resulted in the annual models listed in Table 9.5. The Chisquare and F-statistics are extremely significant at nearly the 0.00 level. The number of ratios in each annual model was limited to that beyond which only negligible discriminating power was added to the models in terms of Wilk's Lambda. Comparison of the

above models with those derived in the case of the 14 industries (Table 8.2) and the 4 super-industries (Table 9.2) shows that the most important discriminators are common to all models. As regards the relative importance of the ratios in the 3-group models, rankings by discriminant power measured in terms of the scaled-weighted method

1972		1973		1974		1975		1976		1977	
Ratio	DP	Ratio	DP	Ratio	DP	Ratio	DP	Ratio	DP	Ratio	DP
$\frac{Dr}{INV}$	28	$\frac{Dr}{INV}$	21	Days Drs	29	Days Drs	27	$\frac{Dr}{CA}$	30	$\frac{Dr}{CA}$	29
Days Drs	20	$\frac{VA}{ANCE}$	21	$\frac{S}{AINV}$	25	$\frac{VA}{ANCE}$	23	Days Drs	16	$\frac{VA}{ANCE}$	20
$\frac{VA}{ANCE}$	16	Days Drs	14	$\frac{VA}{ATCE}$	22	$\frac{Dr}{CA}$	18	$\frac{VA}{ANCE}$	14	Days Drs	17
Sale	11	$\frac{Debt}{TA}$	14	$\frac{Dr}{Cr}$	10	$\frac{EBIT}{S}$	12	$\frac{EBIT}{ATCE}$	12	$\frac{PBT}{ATCE}$	11
$\frac{Debt}{TNW}$	11	Sale	12	$\frac{EBIT}{S}$	9	$\frac{ACr}{COS}$	10	$\frac{CL}{Cr}$	11	$\frac{CA}{TA}$	8
$\frac{CA}{TA}$	9	$\frac{AWC}{S}$	12	$\frac{OSCF}{AOSE}$	6	TNW	10	$\frac{CA}{TA}$	9	$\frac{ACr}{COS}$	7
$\frac{ACr}{COS}$	6	$\frac{TNW}{ACL}$	6					TNW	7	Total Asset	7
λ	.39		.36		.35		.38		.36		.35
χ^2	245.29		267.22		270.50		252.48		267.70		260.20
	(14)		(14)		(12)		(12)		(14)		(14)
F	22.06		24.59		29.19		26.73		24.65		24.10
	(14,510)		(14,510)		(12,512)		(12,512)		(14,510)		(14,484)
α	0.00		0.00		0.00		0.00		0.00		0.00

Table 9.5: 3 Group Discriminant Models and Their Discriminant Power %

Note: DF = degrees of freedom.

Figures in parentheses are degrees of freedom.

α = the level of significance,

For key to λ , χ^2 , F and DP see Table 8.2.

are shown in Table 9.5. A more meaningful comparison may be made in terms of the composition of the discriminant models in the 14-, 4-, and 3-group analysis, that is, in terms of the dimensions represented and their discriminating power. For the three group case the dimensional affiliations and discriminating power are shown in Tables 9.6 and 9.7.

1972	1973	1974	1975	1976	1977
Ratio Dim	Ratio Dim	Ratio Dim	Ratio Dim	Ratio Dim	Ratio Dim
Dr/INV SL	Dr/INV SL	DaysDrs TO	DaysDrs TO	Dr/CA SL	Dr/CA SL
DaysDrs TO	VA/ANCE LI	AINV/S SL	VA/ANCE LI	DaysDrs TO	VA/ANCE LI
VA/ANCE LI	DaysDrs TO	VA/ATCE LI	Dr/CA SL	VA/ANCE LI	DaysDrs TO
Sale Size	$\frac{\text{Debt}}{\text{TA}}$ LTS	Dr/Cr TCr	EBIT/S PFT	$\frac{\text{EBIT}}{\text{ATCE}}$ PFT	$\frac{\text{PBT}}{\text{ATCE}}$ PFT
$\frac{\text{Debt}}{\text{TNW}}$ LTS	Sale Size	EBIT/S PFT	ACr/COS TCr	CL/Cr TCr	CA/TA STAI
CA/TA STAI	AWC/S STS	$\frac{\text{OSCF}}{\text{AOSE}}$ PFT	TNW Size	CA/TA STAI	ACr/COS TCr
ACr/COS TCr	$\frac{\text{TNI}}{\text{ACL}}$ PFT			TNW Size	Total Size Assets

Table 9.6: Dimensions Represented in the 3-group Discriminant Models

Note: for key to the abbreviations see Table 8.4.

Dimension	1972	1973	1974	1975	1976	1977
Structural Liquidity	28	21	25	18	30	29
Turnover	20	14	29	27	16	17
Labour Intensity	16	21	22	23	14	20
Profitability	-	6	15 ^a	12	12	11
Trade Creditors	6	-	10	10	11	7
Size	11	12	-	10	7	7
Short Term Asset Intensity	9	-	-	-	9	8
Long Term Solvency	11	14	-	-	-	-
Short Term Solvency	-	12	-	-	-	-

Table 9.7: Discriminating Power of the Dimensions (in percent)

a = the sum of two profitability ratios, their discriminating power being treated as additive.

9.2. 3 Comparison of the relative importance of the dimensions in the 14 industry (Table 8.4) and 3 super-industry discriminant models reveals some interesting differences. Structural Liquidity is more important than Turnover in the 3 group case whereas the positions are reversed in the 14 industry models. This appears to emphasise the much more sharply defined differences in the importance of inventory in the current asset composition of the super-industries. However, the difference is not always consistent or substantial in magnitude. A much more significant difference is the emergence of Size as a modest but consistent discriminator among the super-industries. This suggests that operating scale might not be a distinguishing feature of any particular basic industry but may be of groups of industries with distinct production technology, age and other fundamental characteristics. We shall return to this aspect when we discuss the economic significance of the discriminators. The other dimensions do not differ widely.

9.2. 4 Validity of Underlying Assumptions: Since the constituent ratios of the annual models are not distributed normally as indicated by the statistics on the univariate distributions provided in Appendix 5.8 there was little point in testing for multivariate normality. However, in order to determine whether the linear or quadratic classification rule was more appropriate the equality of dispersion matrices of the three super-industries was tested. The F-statistics for the test are shown in Table 9.8. The associated levels of significance indicate that the null hypothesis could not be rejected at the 0.05 level in 1974 and 1977 and at the 0.01 level in 1973. In the other years the levels of significance are much higher than in the case of the basic industries. Firms within the super-industries thus appear to be more uniformly distributed than when they are confined to disaggregated industries indicating the more homogeneous character of the super-industries. However, the null hypothesis of equality cannot be accepted consistently. Therefore, the need for a quadratic classification rule cannot be rejected.

Year	F-statistic	Degrees of freedom	Level of Significance
1972	2.58	56 & 159163	.000
1973	1.78	"	.031
1974	1.77	42 & 165121	.156
1975	2.11	"	.004
1976	2.03	56 & 159163	.001
1977	1.59	56 & 147368	.323

Table 9.8: Test of Equality of Dispersion Matrices

Note: For computation of F ratio see Eisenbeis & Avery (1972), Appendix 1B.

9.3 Classificatory Power of the Discriminant Ratios

- 9.3.1 Table 9.9 shows the correct classification rates in percent achieved by the annual models under the OS method. With the linear rule the overall rate of correct classification ranges from 74.2% in 1975 to 78.4% in 1974 but with the quadratic rule there is a slightly smaller variation from 73.7% in 1977 to 76.5% in 1976. The maximum difference in classification accuracy between the two rules is only 2.3% in 1974. The performance of the two rules may, therefore, be regarded as practically identical.

Year	Linear Rule (%)				Quadratic Rule (%)			
	PRCS	ENGG	TEXT	OVERALL	PRCS	ENGG	TEXT	OVERALL
1972	80.6	75.3	76.1	77.7	74.1	76.5	78.9	76.1
1973	75.9	80.0	71.8	76.1	75.0	81.2	71.8	76.1
1974	79.6	80.0	74.6	78.4	76.9	78.8	71.8	76.1
1975	75.0	75.3	71.8	74.2	75.9	74.1	71.8	74.2
1976	81.5	76.5	70.4	76.9	79.6	76.5	71.8	76.5
1977	78.4	72.5	73.9	75.3	76.5	71.3	72.5	73.7
Average	78.5	76.6	73.1	76.4	76.3	76.4	73.1	75.5

Table 9.9: Classificatory Power of Discriminant Models (OS method)^a

a- only group and overall correct classification rates are shown in the Table.

9.3. 2 Classification was also performed using the Lachenbruch Holdout method. The results presented in Table 9.10 show that the linear rule performed better in every year but, as would be anticipated, both rules underperformed their respective classification under the OS method. The difference between the two methods was greater when the quadratic rule was used. It would appear that the linear rule is much more robust to the method of classification. The average correct classification by the linear rule under the Lachenbruch method may, therefore, be taken as the best unbiased estimate. This rate was 73.7%.

Year	Linear Rule (%)				Quadratic Rule (%)			
	PRCS	ENGG	TEXT	OVERALL	PRCS	ENGG	TEXT	OVERALL
1972	77.8	71.8	76.1	75.4	66.7	68.2	73.2	69.9
1973	75.0	72.9	69.0	72.7	67.6	74.1	71.8	70.8
1974	76.9	77.6	74.6	76.5	75.9	72.9	66.2	72.3
1975	74.1	71.8	70.4	72.0	67.6	68.2	73.2	69.3
1976	77.8	71.8	67.6	73.1	74.1	69.4	71.8	72.0
1977	76.5	70.0	69.6	72.5	69.6	66.3	68.1	68.1
Average	76.4	72.7	71.2	73.7	70.3	69.9	70.7	70.4

Table 9.10: Classificatory Power of Discriminant Models (LH Method)^a

a- only group and overall correct classification rates are shown in the Table.

9.3. 3 The Stability of Super-industry Groups: The stability of the super-industries over time was assessed by the predictive ability of the annual models tested on the samples of subsequent years (prediction samples). The detailed classification results are shown in Appendix 9.1 while the overall rates of correct classification are shown in Table 9.11. Comparison with the Lachenbruch classification results indicates no systematic decline in the classificatory power of the annual models. Indeed some of the annual models performed better on the prediction samples than on the original samples. Compared with the OS method results, the predictive results show diminished classificatory efficiency with the exception of the 1975 model which achieves greater accuracy. This exceptional feat is probably due to sample bias.

Predicted Year	Base Year									
	1972		1973		1974		1975		1976	
	L	Q	L	Q	L	Q	L	Q	L	Q
1973	75	75								
1974	73	71	73	72						
1975	75	73	69	71	73	74				
1976	71	71	69	68	70	69	76	74		
1977	73	71	69	71	73	72	76	75	74	73
Average	73.4	72.2	70	70.5	72	71.7	76	74.5	74	73

Table 9.11: Predictive Power of 3-Group Discriminant Models (% of correct classification)

Note: L: Linear model; Q = quadratic model.

Base year is the year of the model which was used in prediction.

Average refers to the column average.

The figures in the Table apart from the averages have been rounded to the nearest integer.

9.3. 4 While the overall classification rates varied within a narrow range of less than 5% much wider variations are visible within each super-industry group. These variations seem to afflict the original as well as the prediction samples, the OS and LH methods and both classification rules. We may ignore the OS method because of its proven bias and concentrate on the LH method and the predictive sample (PS) method. Since it is difficult to decide which of these is the better method, a compromise assessment of within-group classification accuracy is to average the 21 classification results for each group (6 annual results and 15 prediction results). The average within group classification accuracy computed in this way is:

	<u>Processing</u>	<u>Engineering</u>	<u>Textiles</u>
Linear Rule	71.6	75.2	72.4
Quadratic Rule	68.3	75.0	72.2

The quadratic rule thus marginally underperforms the linear rule on the whole in addition to showing much greater variation in its assignment to groups as shown by a comparison of the individual group correct classification rates under the two rules in Table 9.10 and Appendix 9.1.

- 9.3. 5 We may judge the performance of the discriminant models against the proportional chance (PC) model as earlier. Based on the formula given in paragraph 7.5.4 and the prior probabilities (assumed equal to the sample proportions, see Table 9.4) the classificatory efficiency of the PC model would be 34.3%. Compared to this, the least efficient discriminant model (the quadratic under the LA method in 1977, see Table 9.10) has a classificatory accuracy of 68.1%. This model is very much superior to the PC model the difference being statistically significant at better than 0.001 level ³.
- 9.3. 6 The overall average correct classification rate of 73.7% is a significant improvement over the results obtained in the case of the 14 industry analysis - 30.9% (see Table 8.5). Compared to the 4 group analysis, the improvement is much smaller (see Table 9.3)⁴. The aggregation of the 14 industries into a smaller number of super-industries may, therefore, be justified. However, the aggregation of Food with other Processing industries has resulted only in a small increase in the homogeneity of the super-industries. This suggests that Food is fairly distinct and that its separate identity cannot be attributed to vertical integration alone (see paragraphs 9.1.6 to 9.1.8).

9.4 The Industrial Rationale for the Construction of the Super-industries

- 9.4. 1 The empirical aggregation of the basic industries into three super-industries has been shown to be justified in terms of statistical results. The super-industries however, are not mere statistical conjuring tricks but well founded in industrial logic. We have already mentioned in passing (in paragraph 9.1.5) that the 5 industries in Processing are engaged in the conversion of primary raw materials into consumer or

-
3. The t statistic is 11.3 (see paragraph 7.5.4 on computation) with 250 degrees of freedom.
4. It was 69.0% under linear model Lachenbruch method (see Table 9.3). However, this is a single year's result whereas the average of 73.7% referred to above is based on 21 linear classification results for 6 years. Nevertheless the comparison is not believed to be unrealistic.

intermediate goods. Metallurgical firms process non-ferrous metals like aluminium, copper etc. to produce alloys. They are engaged in smelting, casting and fabrication by rolling, extrusion and drawing. General Chemical firms transform petroleum into organic chemicals such as ethylene, benzene etc. Packaging and paper materials are produced by chemical conversion of woodpulp. Firms producing building materials such as sanitary ware use clay. Food is obviously a process of converting agricultural products.

9.4. 2 The grouping of engineering industries - Electricals, Light Electronics, Industrial Plant, Machine Tools and Motor Components - is also consistent with the nature of the production process involved. These industries are not conversion industries in the same way as the Processing industries are. Rather, they are assembling industries. Different stages of assembly may be carried out by different firms. For example, a firm making power station equipment can either make the components itself or buy them from outside suppliers. Similarly, although machine tools are basically mechanical engineering products, where they are numerically controlled the requisite electronic instruments may be supplied by electronics firms. The difference in the nature of the production process between Processing and Engineering has implications for the degree of labour vs capital intensity, research and development etc. The need for assembly in engineering means that it cannot be automated to the same extent as, say, the production of chemicals. This also means employment of more labour which also has to be skilled. Given the similarities in terms of production process, labour force employed etc. it is perhaps not surprising that Engineering is the most homogeneous of the 3 super-industries (see paragraph 9.3.4).

9.4. 3 The last of the super-industries, Textiles, is made up of Clothing, Wool, Miscellaneous Textiles and Footwear. Under the SIC Clothing and Footwear are grouped together in Order XV whereas Wool and Miscellaneous Textiles are grouped under Order XIII. Our analysis, not surprisingly, reflects this recognition of the similarity of these two pairs of industries. It means that the basis on which the SIC is constructed is reflected in the financial characteristics of the member firms. Our results, however, point to a cross-Order affinity. These industries, however, share some common characteristics. The most unifying influence has

been the development of synthetic fibres.

"The historical branches of the industry (i.e. Textiles and Clothing), based on natural fibres of cotton and wool, linen and jute have retained their separate identities but the boundaries between them are becoming blurred with the increasing use of man-made fibres. The growth of man-made fibres has stimulated the development of new processes and new types of yarn and cloth and has strongly influenced the structure of the industry"⁵.

All the four industries are very sensitive to consumer tastes. Textiles and Clothing are more labour intensive than many other industries⁶.

- 9.4. 4 Broadly similar technology and methods of production within each super-industry has inevitably led to considerable diversification by firms. Gorecki (1975) has developed the concept of a "specific asset" to explain diversification and includes among the different categories of specific asset innovation, basic knowledge and a skilled labour force (p. 132). Discussing the direction of diversification within and among the SIC Orders he says

"...diversification across industries within an Order may be considered to involve less diverse technology...than diversification across industries falling in two or more different Orders. Diversification within industries comparatively homogeneous as to technology is more probable than diversification outside such industries" (p. 133).

He attributes this tendency (p. 133) to the fact that the transfer costs of specific assets of a technological nature are likely to be smaller and information concerning the profitability of opportunities to employ the enterprises' specific assets within groups of homogeneous industries is likely to be available at relatively low cost.

- 9.4. 5 In his analysis of diversification in the manufacturing sector both within and across SIC Orders for the year 1963 Gorecki (1975) found:

5. See Central Office of Information (1977), p. 15.

6. See National Economic Development Office (1974).

- a) that much diversification took place within Orders; this was particularly true of enterprises classified to certain Orders, most notably Food, Drink and Tobacco, Engineering and Electrical Goods, Textiles and Paper, Printing and Publishing (p. 134).
- b) that "specific assets of a technological nature formed the basis of much diversification" (p. 134); and in general, "enterprises diversified to a large extent within a group of industries that could be considered homogeneous in a technological sense" (p. 143) and
- c) that "enterprises classified to the Clothing Industry diversified largely within Order X, Textiles" (p. 136).

9.4. 6 In a more recent study (1977) Utton defined two components of diversification:

- 1) narrow spectrum diversification i.e. into closely connected industries (measured by diversification into three-digit industries within the same Order) and
- 2) broad spectrum diversification (measured by the spread of the firm's employment into three-digit industries of different Orders).

He investigated the extent of narrow and broad spectrum diversification in 200 large U.K. manufacturing firms using employment data relating to 1974 which falls within the period of our analysis.

9.4. 7 Utton's findings may be summarised as follows:

- a) "nearly half of textile enterprises' employment outside their primary Order (i.e. 1968 SIC Order XIII) was in Clothing and Foodwear industry" (p. 105) ⁷.
- b) Food, Drink and Tobacco exhibited very high narrow spectrum diversification with 73% of the secondary employment of firms in that Order confined to the three-digit industries of the same Order against an average of 55% for all manufacturing Orders (p. 108). ⁸.

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- 7. Utton (p.105) attributes much of this diversification to Courtalds forward vertical integration by merger into the clothing industry to protect its outlets for cellulosic fibre. Courtalds, however, is not included in our sample. The homogeneity among Textiles, Wool, Clothing and Footwear observed in our analysis, therefore, points to a more widespread diversification than can be accounted for by a single company.
 - 8. This appears to confirm our earlier result (see paragraph 9.3.6) that Food was a fairly distinct industry, see also Gorecki's (1975) result in paragraph 9.4.5. above.

- c) If Mechanical Engineering, Electrical Engineering, Vehicles and Metal Goods not elsewhere specified were treated as one unit i.e. as Engineering and Vehicles, narrow spectrum diversification for the sector was 73%. "Nearly three quarters of (the sector's) diversification is into industries which are likely to have similar production methods or to be in an earlier or later phase of the production process, reflecting vertical integration" (p. 110).
- d) "the data...suggest that firms concentrate on diversification into closely related industries" (p. 111).

9.4. 8 Hassid (1975) found that similarity of technical skills required by technologically similar industries was often conducive to diversification. He observed a strong positive relationship between "technical personnel ratio" and diversification. According to him

"...the basic argument has been that the existence of highly developed skills, in industries like Chemicals, Petroleum products and the whole area of Engineering not only promotes productivity within the main activity but, at the same time, makes easier the adjustment of already familiar production processes to the requirements of other industries" (p. 389).

9.4. 9 The results of our analysis of the 14 manufacturing industries described in the last chapter and of the four and three super-industries earlier in this chapter, are broadly consistent with the conclusions of Gorecki, Hassid and Utton despite the difference in the industrial classification systems employed^{9,10}. Moreover,

"the number of independent enterprises in engineering has been greatly reduced in recent years not so much by horizontal or vertical mergers in the strict sense, but rather by the trend towards diversification... the extension of electric lamp making into valves and the incursions of electrical firms into newer and more advanced forms of electronics provide examples of diversification brought about by new technological opportunities" (Hays, 1972, pp. 80-81).

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- 9. Gorecki (1975) used the 1963 Standard Industrial Classification (SIC), Hassid (1975) both the 1963 & 1968 & Utton (1977) the 1968 classification.
 - 10. The Gorecki & Hassid studies used aggregate industry data & analysed diversification at the industry level. Our data are, however, company level data. For lack of detailed information in published financial statements no detailed analysis of diversification at the company level could be carried out.

In the chemical industry

"as the result of a series of mergers, production has to a considerable extent become concentrated in the hands of leading companies and very large firms, with a wide range of products, are responsible for much of the output of the industry as a whole" ¹¹.

Examples of such diversified firms in our sample are Imperial Chemical Industries, Albright and Wilson and Unilever. Such diversification is perhaps one of the chief reasons for the similarity of the financial characteristics of firms within each super-industry transcending the narrower confines of the basic industries ¹².

- 9.4. 10 Our results are also consistent with Eugene's (1977) findings that most of the misclassifications in his 10 industry discriminant analysis "occurred among electrical goods, machinery, automotive goods and other manufacturing industries" (p. 99). A high degree of similarity in the financial profiles of firms in these industries was demonstrated when he reclassified the firms in these industries into a single industry and repeated his analysis. He found the aggregated industry more homogeneous leading to substantially higher rates of correct classification (p. 99) (see Chapter 4 for a discussion of Eugene's study).
- 9.4. 11 The construction of super-industries is, therefore, not only founded on sound industrial rationale based on the many common fundamental characteristics of the constituent industries but it is also consistent with the evidence on diversification among technologically similar industries. However, since the aggregation into super-industries was based on the discriminating ratios we have to examine how far these are in tune with the fundamental characteristics.
- 9.4. 12 Super-industry Characteristics and The Discriminant Ratios: The relationship may be examined in terms of the mean values of those ratios which were consistently good discriminators. These values are provided in Table 9.12.

11. See Central Office of Information (1978) p. 9.

12. The qualification made in footnote 10 above also applies to this statement.

Super-industry	Discriminant Ratios							
	Days Drs	Dr/CA	Log VA ANCE	SQRT EBIT ATCE	Log TNW	SQRT ACr COS	CA/TA	Debt/TA
Processing	64.03	.50	-.29	.71	9.45	.40	.63	.15
Engineering	75.48	.42	-.10	.74	9.36	.45	.72	.12
Textiles	49.65	.34	-.06	.69	8.52	.37	.71	.16
F-statistic (2,261) ¹	42.01	61.63	8.99	7.84	9.87	30.94	23.00	3.18

Table 9.12: Means of Super-industries on Discriminators (1976) ²

Note: 1. degrees of freedom.

2. broadly similar results were obtained for the other years.

9.4. 13 All the discriminators except Size and Long Term Solvency (LTS) appeared in the 14 industry models (see Table 8.2). The ranking of the super-industries is broadly similar to the ranking of the basic industries observed in the last chapter, (see Table 8.11) which was explained in terms of their underlying economic attributes viz. nature of product, technology, capital intensity etc. (see Section 8.4). Since the relative positions of the super-industries can be explained by the same factors the discussion need not be repeated here. However, the two dimensions Size and LTS need to be examined. As regards Size measured, for example, in terms of Total Net Worth ¹³, firms of similar size could be found in several of the basic industries. So on the basis of size alone we cannot tell them apart. For example, broadly similar sized firms are operating in Electricals and Electronics (e.g. Thorn Electrical Industries and General Electric Company) or in Chemicals and Food (e.g. Imperial Chemical Industries and Unilever). However when considered on a super-industry basis, firms within one super-industry can be distinguished from those in another ¹⁴.

13. The logarithmic mean values of Total Net Worth for the 3 super-industries in 1976 were: Processing = 9.45, Engineering = 9.36 and Textiles = 8.52. Since the mean correlation between Total Net Worth and the other measures of size was 0.99, it is unnecessary to consider the latter.

14. This conclusion is probably valid only for the sample analysed since our sample does not cover the entire range of firm size (see Section 5.1).

9.4. 14 The largest super-industry in terms of average company size is Processing and the smallest, Textiles. We have already seen that Processing industries are the most capital intensive among manufacturing industries. Clothing and Footwear on the other hand, were the least capital intensive industries, whereas the Engineering industries and Textiles were intermediate between the two extremes (see Table 8.11). The reasons for the relative levels of capital intensity were discussed in paragraphs 8.4.12 and 8.4.13. The relative rankings of the super-industries on size are, therefore, quite consistent with the underlying structure of those industries.

9.4. 15 LTS measured by Debt/TA indicates reliance on long-term debt or bank loans and overdrafts. Textiles are the most dependent on debt and Engineering the least. We have shown that Textile firms may be relying on bank finance to carry large inventories (see paragraph 8.4.10). On the other hand the Processing industries may rely on long term debt to finance their large capital investment. However, since LTS was not a consistent or powerful discriminator (see Table 9.7) the differences among super industries on that dimension cannot be exaggerated ¹⁵.

9.5 Summary and Conclusions

9.5. 1 This chapter described our search for homogeneous groups of industries. Following the results of the 14 industry analysis which suggested four empirical groupings of the basic industries we attempted a 4-group analysis - Processing, Textiles, Engineering and Food. Food, however, appeared to be less homogeneous than the other three. A possible reason for the separate but weak identity was thought to be the relatively high degree of vertical integration between manufacturing and distribution. Once allowance was made for this it was thought that Food would not be distinct from the other processing industries. Food was, therefore, aggregated with Processing and a 3-group discriminant analysis was performed.

15. Eugene (1977) and Chen and Balke (1979) also found the leverage ratio to be unimportant.

- 9.5. 2 The classification results showed that the 3 super-industries were considerably more homogeneous than the 14 basic industries, the average correct classification being 73.7% against 30.9% in the latter case. The relatively small increase in the homogeneity of the super-industries, from the 4-group to 3-group analysis, however, indicated that grouping Food with the other Processing industries was not quite appropriate and that Food was fairly distinct from the latter industries (see paragraph 9.3.6.). This result appeared to receive some support from the studies of both Gorecki (1975) and Utton (1977) (see paragraphs 9.4.5 and 9.4.7 and footnote 8). The empirically assembled super-industries were examined to see whether the groupings were also founded on industrial logic. The homogeneity of the super-industries was shown to result from the similarity of the technology and production processes used by the basic industries and the consequent tendency towards diversification. The discriminating ratios among the super-industries were also related strongly to their underlying economic characteristics.
- 9.5. 3 In this chapter we set out to examine whether aggregation of industries on the basis of financial ratios would yield more homogeneous groupings and whether such groupings would be in accordance with the fundamental economic characteristics of the basic industries (see Section 9.0). From our analysis it appears that homogeneous groupings of industries can be achieved on the basis of similarity of the financial profiles of those industries and that such groupings are consistent with the underlying economic and structural characteristics of the industries concerned. Our argument that such similarity of financial profiles might have resulted, at least partly, from possible diversification among the basic industries received some empirical support from other studies (see Section 9.4). These results thus broadly confirm our thesis that financial ratios and accounting numbers in general have the ability to describe or reflect the economic and structural aspects of industries.
- 9.5. 4 Our analysis has revealed the inability of the Stock Exchange Industrial Classification (SEIC) to produce, at least, in certain cases, homogeneous groupings of firms. The implications of this weakness are discussed in the next chapter which also summarises the results and general implications of the present study.

Chapter 10

Summary, Conclusions and Implications

10.0 Introduction

As stated in the first chapter the broad objective of this study was to examine the appropriateness of using the industry concept in financial analysis. In the light of this objective we formulated (Section 1.3) three specific hypotheses:

- 1) that firms in different industries differed in terms of their accounting numbers
- 2) that accounting numbers of firms have significant descriptive ability for the purpose of reflecting the underlying economic characteristics of their respective industries and
- 3) that industry groups are stable over time in terms of their distinct financial characteristics.

It was also our objective to study whether aggregation of basic industries yielded more homogeneous groupings of firms as regards their distinct financial attributes. In this chapter we summarise the results of our analyses relating to our objectives and to the other areas bearing on financial statement analysis such as the validity of ratio transformation, the dimensionality of accounting data etc. We shall also discuss the implications of these results for both financial analysis and the related areas.

10.1 Discriminant Analysis of Sectors and Manufacturing Industries

- 10.1.1 The discriminant analysis between the manufacturing and distribution sectors and among the 14 manufacturing industries indicated that there were statistically significant differences between the sectors and among the industries in terms of accounting numbers. Our hypotheses that firms in different industries differ in terms of their financial profiles and that accounting numbers have significant descriptive ability and validity are, therefore, clearly supported. Accounting numbers are demonstrably capable of reflecting those inter-industry differences which arise from differences in the nature of the products

sold, the length and technological characteristics of the production process and age as well as in the investment and financing strategies pursued by firms in different industries. (Section 7.6, 8.4 and 9.4). Both inter-sector and inter-industry differences in accounting numbers also persisted over time. Thus our third hypothesis of temporal stability is also acceptable, at least in the short term.

10.1. 2 Demonstration of the descriptive validity of accounting numbers is important for two reasons. Firstly it justifies the use of financial statements in financial analysis. Secondly, it enables the construction of formal models to represent the functional relationship between economic characteristics of firms' environment and their accounting numbers. A preliminary step in the construction of such models is to establish which accounting numbers actually reflect the economic factors of interest to the researcher. For example in studying the differential impact of monetary policies on trade credit in different industries ¹ it would be useful to establish that there are differences between industries in terms of trade credit variables. Moreover, the identification of variables which genuinely and meaningfully reflect inter-industry differences means that studies concerned with these differences need only concentrate on those variables. In the literature, the non-availability of empirical evidence concerning which ratios best reflect inter-industry differences has led to vague and irrelevant criteria being used to select ratios ². The present study goes some way towards filling this gap.

10.1. 3 Inter-industry differences were discernible only in the case of some ratios and not others. Moreover, even the industry-discriminating ratios did not all have the same degree of discriminating power. This means that comparing a firm's ratio with the corresponding industry average may not be a very meaningful exercise in the case of ratios which discriminate little or not at all among different industries.

1. For a study investigating such a relationship see Whittington (1971).

2. For example, Falk and Heintz (1977, p. 8) cite relevance, popularity, past performance and clarity of interpretation as the criteria to select ratios to represent industry and firm risk.

It would suffice to compare the firm with the economy average ³. The concept of industry average is not useful in that case. Failure to confine the use of industry averages or other measures of central tendency to genuinely industry-differentiating ratios only serves to obfuscate and complicate financial analysis. Financial analyst firms such as Dun and Bradstreet are often guilty of this failure ⁴.

10.1. 4 Indeed only three or four dimensions were able to account for most of the discriminating power of our models. Turnover was the most important indicating the importance of both the totality and the individual components of assets in relation to sales. Less powerful than Turnover were Short Term Asset Intensity, Structural Liquidity and the Solvency dimensions. But together they emphasise the pre-eminence of the balance sheet variables as reflectors of inter-industry differences. This is not surprising since the balance sheet is a long term statement despite being described as a snap-shot picture. The asset and liability structures embodied in a balance sheet are, on the asset side, the result of long-term structural features of an industry such as production technology, product life and trade custom and, on the liability side, of the long-term financing strategies pursued by the firm and trade custom. Since the asset structure embodies so much that is industry specific and, therefore, largely outside the influence of the firm's discretionary policies it is probably much more important than the liability structure which is more directly and substantially affected by the firm's policies. The smaller discriminating power of the liability structure vis-a-vis the asset structure was definitely confirmed by our results showing the Solvency dimensions to be of minor importance (see Tables 7.7 and 8.4) ⁵.

10.1. 5 Value added ratios were seen to be the second most important discriminators among industries. The reasons for the high

3. See Foster (1978, p. 58).

4. See for example, their "Management Ratios".

5. See Rudolph (1979, p. 138) on the industry effects on the balance sheet structure. Eugene (1977) and Chen & Balke (1979) also found the leverage ratios to be unimportant.

discriminating power of value added were discussed in Sections 7.6, 8.4 and 9.4. Value added ratios embody a major aspect of industries, namely, the level of capital to labour intensity and the nature of the workforce which is determined by the level of technology used. Thus they have very significant informational content. In financial analysis until recently value added was not widely used partly because of the non-availability of employee remuneration data in published accounts. Indeed during our analysis of our results we had occasion to refer to this deficiency (paragraph 7.7.4). But with the increasing reporting of value added data, value added ratios must gain an important place in financial analysis especially when the focus is on inter-industry differences.

- 10.1. 6 Profitability was less important as a discriminator especially when surrogated by return on assets or capital. Cash flow ratios and profit margin ratios were more important than return on assets indicating the prevalence of inter-industry differences in cost structure (i.e. fixed vs variable costs) and a tendency for overall return on assets to equalise⁶. The discriminating power of the cash flow ratios is both interesting and significant since business risk is often defined in terms of variability of cash flow (see paragraph 2.3.4). However, return on capital employed was relatively more important when the differences among the super-industries were analysed (See Table 9.5). This means that within broad industrial categories competitive forces appear to operate to equalise profit rates whereas between those categories it appears that differences in profit rates may persist. The reasons for this phenomenon are perhaps:
- 1) greater mobility and diversification of firms within a super-industry
 - 2) broadly similar cost structures caused by similarity of technology, products, capital intensity and workforce composition⁷.

- 10.1. 7 Approaches to Evaluating Accounting Information: Although controversy over the objectives of financial statements and the criteria for evaluating them has raged for several years now, the shortcomings of

6. See Whittington (1971), Eugene (1977) and Chen & Balke (1979).

Samuels et al (1969), however, found some inter-industry differences in profit rates.

7. See Section 9.4 for a more detailed discussion.

such criteria as predictive ability, decision-usefulness, materiality etc. have not been comprehensively discussed in the literature. Although the two criteria most widely discussed in the literature, predictive ability and decision-usefulness, have considerable intuitive appeal they suffer from either conceptual or methodological weaknesses or both. While predictive ability is inconsistent with the nature of accounting, decision usefulness is flawed by definitional inexactitude as well as the almost insurmountable problems of assessing it empirically. Our discussion emphasised the vital need to evolve criteria which would be consistent with the process of accounting. This means that they should be derived from normative principles and not merely from pragmatic empiricism or user-dictated imperatives. While the latter consideration is important in the communicative context of accounting it is probably not relevant in the context of accounting as a measurement process. We demonstrated that, in terms of a criterion derived in consonance with the nature of accounting, that is, descriptive ability, accounting numbers have significant informational validity.

10.1. 8 Homogeneity of Industry Groups and Stock Exchange Industrial Classification:

Our analysis indicated that several industry groups were non-homogeneous. Some industries showed considerable cross-sector affiliation in the MFG-DIST analysis implying a substantial degree of vertical integration. Similarly, some of the manufacturing industries displayed much heterogeneity. Given this lack of homogeneity, it is arguable that the SEIC has fallen short of its objective to produce "groups of companies whose results are likely to be affected by the same economic, political and trade influences"⁸. Moreover, it has been argued by Short & Brumwell, (1973, p. 4) that "the acceptance of (SEIC) by the investment world is an adequate testimonial" of its validity. This complacent attitude is, however, not wholly warranted by our empirical results. Since a major assumption of financial analysis in using the industry framework is that the industry groups are homogeneous and since this assumption is not valid in the case of certain industries there is no justification for maintaining the fiction that separate industry analysis is appropriate in all cases.

8. See Paragraph 2.2.11 for a discussion of the basis of SEIC.

10.1. 9 The greater homogeneity of super-industries means that use of industry groups at a higher level of aggregation than the SEIC would be more appropriate in financial analysis⁹. It would appear that the pre-dominantly end-product based SEIC does not lead to highly homogeneous groups. Our results indicate that, in designing homogeneous industry groups, greater importance should be attached to other criteria such as production process, complementarity of products and technology and potential diversification and competition. It would be recalled from Chapter 2 (paragraph 2.2.4) that Andrews had described the chief characteristic of an industry as:

"largely a matter of technique and process; an individual business must be conceived as operating within an "industry" which consists of all businesses which operate processes of a similar kind (which implies the possession of substantially similar technical resources) and possessing sufficiently similar backgrounds of experience and knowledge so that each of them could produce the particular commodity under consideration and would do so if it were sufficiently attractive".

10.1. 10 Brunner's suggestion (paragraph 2.2.5) that this chief characteristic be adopted as the definition of industry is well supported by the composition of the super-industry groups in our analysis. Each of the super-industries is made up of industries which eminently satisfy the condition that they operate substantially similar processes and also possess similar technical resources and backgrounds of experience and knowledge, e.g., Electricals and Electronics, Textiles, Wool and Clothing, Packaging and Paper and Chemicals (see Section 9.4). Wilson (1958) proposed that in addition to competitiveness of the products sold, complementarity of products and technology and the potential competition among firms which presently produce different products must be taken into account in defining an industry. The close affinity among the industries constituting the super-industries reinforces the strength of Wilson's proposal. In the light of this, SEIC criteria must be reappraised and formulated afresh.

9. Whether firms within a super-industry are homogeneous with respect to stock market risk-return parameters needs to be empirically tested. See Section 10.5.

- 10.1. 11 Evidence on Diversification and Vertical Integration: Our results pointed to some degree of diversification especially among industries within the super-industry groups which for the reasons set out in the last two paragraphs, seems wholly plausible. However, the absence of much detailed information in published accounts precluded a thorough analysis and precise estimate of the degree of diversification. A few industries also exhibited considerable forward or backward integration (see Section 7.7). However, because of the limited number of industries and the small sample size of some of the industries included in our samples, we cannot generalise our results to the whole of the U.K. manufacturing and distribution sectors. It appears, however, that discriminant analysis could be used to analyse vertical integration and diversification among firms. This technique has not been used in previous studies addressed to this question.
- 10.1. 12 Another important issue bearing on the question of vertical integration is the metric to be used to measure it. The ratio Value Added/Sales has been proposed in the literature on the ground that value added by an integrated firm will be higher than by a non-integrated firm ¹⁰. There are, however, several problems associated with this measure. It has been argued that at the industry level, VA/S may not be accurately compiled since the unit of account in industrial classification data is the establishment whereas it must be more properly computed from company data ¹¹. Moreover, value added is affected by other factors such as overseas diversification (with differences in wage levels), the extent of labour intensity etc. Thus it may not be an accurate measure of vertical integration. Our results also show that Timber, Building Materials and Special Steels which evinced a high degree of backward integration were not particularly distinguished on VA/S from the average distribution firm (Section 7.7). Should VA/S be a good indicator of integration they would have been closer to the average manufacturing firm. This illustrates the problem in using a single metric such as VA/S ¹². As our analysis shows integration could be

10. Pickering (1976). More recently Tucker and Wilder (1977).

11. Eckard Jr. (1979).

12. The weaknesses of value added computations in our data must be noted in this regard (see paragraph 7.7.4).

manifested in other financial characteristics such as turnover of assets, short term solvency etc. A composite multivariate measure can, therefore, be used in the place of a single and imprecise metric.

10.2 Methodological Significance of the Study

10.2. 1 The results of our study provide some useful and interesting evidence concerning two major issues in the use of discriminant analysis:

- 1) Validation Techniques and
- 2) The relative merits of the linear and quadratic classification rules.

The issues involved were discussed in Sections 7.4 and 7.5. It was indicated that these issues were still theoretically unresolved. The applied researcher has, therefore, to rely on prior empirical research to guide him in the choice of the appropriate validation and classification techniques. The results of our analyses are, therefore, particularly significant from the methodological point of view and are summarised below.

10.2. 2 Evidence on Validation Techniques:

- 1) When the groups were well separated as in the case of the MFG-DIST and the 3 super-industries analyses there was little difference in the classificatory efficiency of the Original Sample (OS), Lachenbruch Holdout (LH) and Prediction Sample (PS) validation methods ¹³.
- 2) When the group sample sizes were small and the groups were overlapping as in the 14-industry case
 - a) the OS method appeared to be more biased upwards and this bias appeared to be greater with the quadratic than with the linear rule probably due to overfitting - a result consistent with the results of some earlier studies ¹⁴.
 - b) the LH method appeared to be more robust to deviations from equality of dispersion matrices than the OS method as indicated by the closer agreement between the linear and quadratic rule classification results ¹⁵ and

13. See Sections 7.5, 8.3, 9.1 and 9.3.

14. See Eisenbeis (1977), Lachenbruch and Goldstein (1979) for a review of these studies. See also paragraphs 8.3.5 and 8.3.6.

15. See Tables 8.5 and 8.7.

- c) the PS method appeared to produce the least bias and the most agreement between the linear and quadratic rules ¹⁶. The use of temporal validation samples, however, depends on the assumption of stationarity of the group differential attributes over time ¹⁷.

10.2. 3 Evidence on Classification Rules:

- 1) When group sample sizes were large and the groups well separated, linear and quadratic rule classification rates differed very little although dispersion matrices were unequal and the quadratic rule was theoretically the appropriate rule ¹⁸. This appears to indicate the robustness of the linear rule to deviations from the dispersion equality assumption.
- 2) When the groups were not well separated and the group sample sizes were small the quadratic rule showed much greater variability in the correct classification rates across different validation techniques than the linear rule. The quadratic rule thus appears to be more sensitive to the validation technique used ¹⁹.

In conclusion our results indicate that the quadratic rule offers no convincing advantage over the linear rule and also emphasise the importance of sample size and sharpness of group separation.

10.3 Validity of Ratio Transformation:

- 10.3. 1 This study represents the first major attempt in the literature to empirically test the major assumptions such as homogeneity, linearity etc. underlying the widespread use of financial ratios as a means of analysing financial statements. We examined the consequences of improper ratio transformation in the light of empirical results. Specifically, we found that the homogeneity condition was more likely to be satisfied by profit and loss account variables than by balance sheet variables and that, despite the violation of this condition, in practice ratio transformation could be beneficial in removing

16. See Table 8.8.

17. See Joy & Tollefson (1975).

18. See paragraphs 7.5.8, 9.3.1 and 9.3.2.

19. See Tables 8.5, 8.7, 8.8, 9.3 and 9.9 to 9.11.

heteroscedasticity or in mitigating its effects. It was argued that under certain conditions the benefits arising from ratio transformation could outweigh the possible bias resulting from non-homogeneity in the case of certain balance sheet variables. Our analysis of the problem of spurious correlation pointed to the definitional ambiguities in the extant literature and also indicated that concern over the problem might be exaggerated and that under certain conditions ratio correlation might indeed closely approximate the "true" residual correlation (see Section 5.6). Our results go some way towards strengthening the empirical basis of both univariate and multivariate financial ratio analysis.

10.3. 2 We also tested the assumption of normality of ratio distributions on a large number of ratios (Section 5.7). The ratio distributions were analysed using chisquare, skew and kurtosis statistics. Previous studies tended to concentrate on chisquare statistics which are quite sensitive to extreme values. Since symmetry is a desirable distributional property studying the skewness of the distribution is a useful exercise. We examined four different transformations log, square root, reciprocal and square root of reciprocal with a view to identifying the "best" transformation. Although none of the ratios became normal under transformation some of the transformations decidedly diminished the degree of non-normality and asymmetry. In terms of the number of ratios examined, statistics used and transformations studied this study is much more comprehensive than any previously reported in the U.K. or the U.S.A.

10.4 Principal Components Analysis (PCA) Results:

10.4. 1 The PCA carried out as part of this study is the first comprehensive U.K. study of its kind covering both the manufacturing and distribution sectors and both orthogonal and obliques rotations. Our results showed that accounting data and the numerous ratios used in practical financial analysis measured only a small number of fairly independent and distinct dimensions. Based on these results one can choose a compact and informationally comprehensive set of ratios to represent the important financial dimensions of firms. Selection of ratios on this basis

avoids needless redundancy in the use of financial ratios and thereby simplifies financial analysis ²⁰. Moreover, where different studies have employed different ratios we can use the PCA results to identify the dimensions represented by those ratios thereby reconciling seemingly different studies. Enhancing inter-study comparability facilitates the development of a cohesive body of empirical literature which is a necessary condition if viable theories are to be formulated on the basis of empirical evidence ²¹.

10.5. Further Research:

10.5. 1 This study was concerned mainly with the use of the industry concept in financial analysis and showed that at least some industries were fairly homogeneous and distinct with regard to their financial characteristics. The classification system viz., SEIC used widely by financial and investment analysts in the U.K. was not altogether satisfactory in producing highly homogeneous groups of firms and greater homogeneity could be achieved by aggregating basic SEIC industries. Our conclusions have, however, been based on a limited sample of firms and industries. A fruitful line of further research is the investigation of an enlarged sample that includes a larger number of industries and firms. The discriminant analysis methodology used in this study appears to be a useful technique for identifying homogeneous groups of firms. The results from such an extended analysis may provide a basis for reappraising and reformulating the criteria that underlie the present SEIC.

10.5. 2 Since an implicit assumption behind the formation of homogeneous groups of firms using the SEIC is that these firms are also likely to be homogeneous with respect to their stock-market risk-return parameters, or, in other words, with respect to their business risk it will be necessary to examine how far any alternative groupings of firms e.g. the super-industries satisfy the above assumption. If, compared to

20. The author's article (with Dr. Taffler) (1980) demonstrates the use of PCA results in evaluating corporate performance.

21. See Chen & Shimerda (1979) for example.

the SEIC such an alternative classification system should produce more homogeneous groups of firms it will lead to more efficient investment and portfolio decisions. If, as was indicated in the present study to be likely, an alternative classification system resulted in more aggregated and, therefore, fewer groups than under the SEIC it will simplify investment analysis since stock selection for portfolio construction purposes may then be made from a smaller number of more genuinely distinct groups of firms.

10.5. 3 Some of the results of this study relating to diversification and integration were seen to be consistent with the results obtained by researchers in the field of industrial economics using the industry level SIC data. Although use of industry level data is clearly unsatisfactory lack of data about individual companies has in the past precluded a more rigorous and meaningful analysis of the extent of diversification and integration among firms. With the increasing trend towards segmental and value added reporting by companies, there may, in the near future, be greater opportunities for examining these phenomena and their implications for corporate finance.

Appendix 5.1.

Industries included in the Manufacturing and Distribution
Samples

<u>Industry Description</u>	<u>SEIC code</u>
Cold formed Fastenings & Turned Parts	11
Bricks & Roofing Tiles	12
Builders Merchants ¹	13
Building Materials/Quarry Products/Asbestos	14
Cement & Concrete	15
Paint	16
Timber	17
Electricals (excluding Light Electronics, Radio and T.V.)	19
Boiler Makers	20
Founders and Stampers	21
Industrial Plant, Engines & Compressors	22
Mechanical Handling	23
Pumps and Valves	24
Steel and Chemical Plant	25
Wires and Ropes	26
Miscellaneous Engineering	27
Machine and Other Tools	28
Heating and Ventilating	30
Instruments	31
Metallurgy	32
Special Steels	33

contd-

Appendix 5.1 (contd)

<u>Industry Description</u>	<u>SEIC code</u>
Light Electronics, Radio and T.V.	35
Radio and T.V. Rental	36
Floor Covering	37
Furniture and Bedding	38
Household Appliances	39
Kitchen and Tableware	40
Motor Components	41
Motor Distributors	42
Motor Vehicles	43
Leisure	48
General Food Manufacturing	49
Milling and Flour Confectionery	50
Food Retailing ¹	51
Packaging and Paper	54
Departmental Stores ¹	55
Furnishing Stores ¹	56
Mail Order Stores ¹	57
Multiple Stores ¹	58
Clothing	59
Cotton and Synthetic	60
Wool	61
Miscellaneous Textiles	62
Footwear	64
Toys and Games	65

contd-

Appendix 5.1 (contd)

<u>Industry Description</u>	<u>SEIC code</u>
Plastic and Rubber Fabricators	66
Pharmaceutical Products	67
General Chemicals	68
Office Equipment	69
Oil	70
Transport, Freight and Fuel	72
Industrial Holding Companies	73
Miscellaneous (Unclassifiable)	76

Notes: 1. These are predominantly distribution sector industries.

2. See also Paragraphs 5.1.3 and 5.1.4 on the criteria for the inclusion of industries in the samples.

3. A more detailed description of the industries can be found in the Stock Exchange Official Year Book..

Appendix 5.2

List of Firms in the Manufacturing Sample

<u>No.</u>	<u>Name</u>	<u>SEIC Code</u>
1	A.B. ELECTRONIC COMPONENTS	35
2	A.C. CARS	43
3	A.P.V. HLDGS	22
4	AARONSON BROS	17
5	ABERTHAW & BRIST CHANN PORTL CEM CO	15
6	ADWEST GROUP	27
7	ALBRIGHT & WILSON	68
8	ALLEBONE & SCNS	64
9	ALLEN (EDGAR) BALFOUR	27
10	ALLIED INSULATORS	19
11	ALLIED POLYMER GROUP ¹	66
12	ALLIED TEXTILE COMPANIES	61
13	ALPINE HLDGS	14
14	AMALGAMATED INDUSTRIALS ¹	27
15	AMALGAMATED POWER ENGINEERING	24
16	ANCHOR CHEMICAL CO	68
17	ANDERSON STRATHCLYDE	22
18	ANDRE SILENTBLOC ¹	27
19	ANGLO-SWISS HLDGS	27
20	ARMITAGE SHANKS GROUP	14
21	ARMSTRONG EQUIPMENT	41
22	ASH & LACY	32
23	ASSOCIATED BISCUIT MANUFACTURERS	50
24	ASSOCIATED BRITISH FOODS	50
25	ASSOCIATED ENGINEERING	41
26	ASSOCIATED PAPER INDUSTRIES	54
27	ASSOCIATED PORTLAND CEMENT MANF ²	15
28	ATKINS BROS (HOSIERY)	59
29	AURORA HLDGS	27
30	AUSTIN (F.) (LEYTON)	38
31	AUTOMOTIVE PRODUCTS	41
32	AVERYS	31
33	AVON RUBBER CO	41
34	AYRSHIRE METAL PRODUCTS	27
35	BABCOCK & WILCOX	20
36	BAIRD (WILLIAM) & CO	59

contd -

37	BAKER PERKINS HLDGS	22
38	BAMFORDS	23
39	BANRO CONSOLIDATED INDUSTRIES	32
40	BARR(A.G.) & CO	49
41	BARR & STROUD	31
42	BARKOW HEPBURN GROUP	64
43	BARTON & SONS	27
44	BASSETT(GEO.) HLDGS	49
45	BATH & PORTLAND GROUP	73
46	BBA GROUP	41
47	BEALES(JOHN) ASSOCIATED COMPANIES	59
48	BEATSON, CLARK & CO	54
49	BEECHAM GROUP	67
50	BEMROSE CORP	54
51	BENFORD CONCRETE MACHINERY	22
52	BERWICK TIMPO	65
53	BESTOBELL	27
54	BIBBY(J.) & SONS	49
55	BIGG	19
56	BIFURCATED ENGINEERING	27
57	BIRMID QUALCAST	27
58	BIRMINGHAM MINT	32
59	BLACKMAN & GGNRAD	59
60	BLACKWOOD, MORTON & SONS(HLDGS)	37
61	BLAGDEN & NOAKES(HLDGS)	54
62	BLAKEY'S(MALLEABLE CASTINGS)	27
63	BLUEMEL BROS	41
64	BLUNDELL-PERMOGLAZE HLDGS	16
65	BOC INT	68
66	BODYCOTE INTERNATIONAL	62
67	BOND STREET FABRICS	62
68	BONSER ENGINEERING	23
69	BOOSEY & HAWKES	48
70	BOOT(HENRY) & SONS	73
71	BOULTON(WILLIAM) GROUP	22
72	BOWATER CORP	73
73	BOWTHORPE-HLDGS	35
74	BPL INDUSTRIES	14
75	BRABY-LESLIE	27
76	BRADY INDUSTRIES	14
77	BRAMMER(H.) & CO	23
78	BRENT CHEMICALS INTERNATIONAL	68
79	BRICKHOUSE DUDLEY	21
80	BRIDON	26
81	BRIDPORT-GUNDRY(HLDGS)	26
82	BRIGHT(JOHN) GROUP	62
83	BRITISH DREDGING CO	14
84	BRITISH ENKALON	60
85	BRITISH INDUSTRIAL HLDGS	73
86	BRITISH MOHAIR SPINNERS	61
87	BRITISH PETROLEUM CO	70
88	BRITISH ROLLMAKERS CORP	25
89	BRITISH STEAM SPECIALTIES GROUP	24
90	BRITISH SUGAR CORP	49
91	BRITISH SYPHON INDUSTRIES	27
92	BRITISH TAR PRODUCTS	68
93	BRITISH VENDING INDUSTRIES	49
94	BRITISH VITA CO	66
95	BRITAINS	73
96	BROCKHOUSE	27
97	BROCKS GROUP OF COMPANIES	76
98	BRONX ENGINEERING HLDGS	25
99	BROUKE TOOL ENGINEERING(HLDGS)	28
100	BROWN BROS CORP	41

101	BROWN(JOHN) & CO	28
102	BRUNTONS(MUSSELBURGH)	26
103	BSR	35
104	BTR	66
105	BULGIN(A.F.) & CO	35
106	BULLOUGH	27
107	BULMER & LUME(HLDGS)	61
108	BUNZL PULP & PAPER	54
109	BURCO DEAN	39
110	BURGESS PRODUCTS CO(HLDGS)	27
111	BURMAH OIL CO	70
112	BURRELL & CO	68
113	BURT BOULTON HLDGS	14
114	BURY & MASCO(HLDGS)	62
115	BUTTERFIELD-HARVEY	27
116	CADBURY SCHWEPES	49
117	CAMREX(HLDGS)	16
118	CANNING(W.)	76
119	CAPE INDUSTRIES	14
120	CAPPER-NEILL	25
121	CAPSEALS	54
122	CARAVANS INTERNATIONAL	43
123	CARGLO ENGINEERING GROUP	27
124	CARLESS CAPEL & LEONARD	68
125	CARLTON INDUSTRIES	73
126	CARPETS INTERNATIONAL	37
127	CARR(JOHN)(DONCASTER)	17
128	CARRINGTON VIYELLA	60
129	CARRON CO(HLDGS)	14
130	CATALIN	68
131	CAWDAW INDUSTRIAL HLDGS	62
132	CELESTION INDUSTRIES	35
133	CENTRAL & SHEERHOOD	73
134	CENTURY OILS GROUP	70
135	CHAMBERLAIN PHIPPS	64
136	CHLORIDE GROUP	19
137	CHUBB & SON	27
138	CHURCH & CO	64
139	CLARKE CHAPMAN	20
140	CLARKE(T.) & CO	19
141	CLAYTON-DEWANDRE HLDGS	41
142	CLAYTON, SON & CO(HLDGS)	27
143	CLIFFORD(CHARLES) INDUSTRIES	32
144	COALITE & CHEMICAL PRODUCTS	72
145	COATES BROS & CO	68
146	COATS PATONS	62
147	COHEN(A.) & CO	32
148	COLE(R.H.)	68
149	COLTNESS GROUP	27
150	COMPAIR	22
151	COMPTON(J.) SONS & WEBB(HLDGS)	59
152	CONCENTRIC	27
153	COPE ALLMAN INTERNATIONAL	73
154	CORAH	59
155	CORNERCROFT	27
156	CORY(HORACE) & CO	16
157	COSALT	76
158	COURTAULDS	60
159	CRANE FRUEHAUF	43
160	CRANE'S SCREW(HLDGS)	27
161	CRODA INTERNATIONAL	68
162	CROPPER(JAMES) & CO	54
163	CROSSLEY BUILDING PRODUCTS	14
164	CROWTHER(JOHN) GROUP	61

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165	CULTER GUARD BRIDGE HLDGS	54
166	DANKS GOWERTON	33
167	DE LA RUE CO	73
168	DELTA METAL CO	32
169	DENBYWARE	40
170	DERITEND STAMPING CO	21
171	DERRITRON	35
172	DESOUTTER BRCS (HLDGS)	28
173	DEVELOPMENT SECURITIES	73
174	DEWHURST & PARTNER	19
175	DICKINSON ROBINSON GROUP	54
176	DIPLOMA INVESTMENTS	73
177	DOBSON PARK INDUSTRIES	27
178	DOLAND (GEORGE)	58
179	DORMAN SMITH HLDGS	19
180	DOWDING & MILLS	19
181	DOWNING (G.H.) & CO	12
182	DOWNS SURGICAL	76
183	DUBILIER	19
184	DUCTILE STEELS	33
185	DUFAY BITUMASTIC	16
186	DUNBEE-COMDEX-MARX	65
187	DUNFORD & ELLIOTT	33
188	DUNLOP HLDGS	41
189	DUPLE INTERNATIONAL	43
190	DUPORT	27
191	DURAPIPE INTERNATIONAL	14
192	DYKES (J.) (HLDGS)	38
193	E.R.E. (HLDGS)	43
194	EARLY (CHARLES) & MARRIOTT (WHITNEY)	61
195	EAST LANCASHIRE PAPER GROUP	54
196	EDBRO (HLDGS)	41
197	ELECO HLDGS	73
198	ELECTRICAL & INDUSTRIAL SECURITIES	27
199	ELECTRONIC MACHINE CO	35
200	ELLIOTT (B.) & CO	28
201	ELLIS & GOLDSTEIN (HLDGS)	59
202	ELSON & ROBBINS	38
203	EMI	48
204	ENERGY SERVICES & ELECTRONICS	35
205	ENGLISH CARD-CLOTHING CO	27
206	ENGLISH CHINA CLAYS	76
207	EUCALYPTUS PULP MILLS	54
208	EVA INDUSTRIES	27
209	EVER READY CO (HLDGS)	35
210	EVERED & CO HLDGS	14
211	EVOJE HLDGS	14
212	EXPANDED METAL CO	27
213	FAIRBAIRN LAWSON	22
214	FARNELL ELECTRONICS	35
215	FEB INTERNATIONAL	68
216	FEDERATED CHEMICAL HLDGS	68
217	FEDEX	49
218	FENNER (J.H.) & CO (HLDGS)	23
219	FIDELITY RADIO	35
220	FISONS	68
221	FLIGHT REFUELLING (HLDGS)	11
222	FLUIDRIVE ENGINEERING CO	23
223	FODENS	43
224	FOGARTY (E.) & CO	62
225	FOLKES (JOHN) HEFU	27
226	FOSECO MINSEP	32
227	FOSTER (JOHN) & SON	61
228	FOTHERGILL & HARVEY	68

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229	FRANCIS INDUSTRIES	73
230	FRENCH (THOMAS) & SCNS	62
231	G.E.I.-INTERNATIONAL	27
232	G.H.P.GROUP	27
233	G.R. (HLDGS)	62
234	GALLENKAMP (A.) & CO	31
235	GARDNER (L.) & SONS	41
236	GARNAR SCOTBLAIR	64
237	GASKELL & CO (BAGUP)	37
238	GENERAL ELECTRIC CO	19
239	GESTETNER HLDGS	69
240	GIBBONS DUDLEY	73
241	GLASS & METAL HLDGS	14
242	GLAXO HLDGS	67
243	GLYNWED	14
244	GOLDREICH (CH.) FOUCCARD & SON	49
245	GOMME HLDGS	38
246	GRAMPIAN HLDGS	73
247	GREEN'S ECONOMISER GROUP	26
248	GUEST, KEEN & NETTLEFOLDS	27
249	HADEN CARRIER	36
250	HAGGAS (JOHN)	61
251	HALL ENGINEERING (HLDGS)	27
252	HALL (MATTHEW) & CO	25
253	HALLAM, SLEIGH & CHESTON	41
254	HALSTEAD (JAMES) (HLDGS)	37
255	HARRIS & SHELDON GROUP	73
256	HAWKER SIDDELEY GROUP	27
257	HAWKINS & TIPSON	26
258	HELENE OF LONDON	58
259	HENDERSON (P.C.) GROUP	14
260	HEPWORTH CERAMIC HLDGS	14
261	HESTAIR	73
262	HICKING PENTECOST & CO	62
263	HICKSON & WELCH (HLDGS)	68
264	HIELD BROS	61
265	HIGHAMS	66
266	HIGHGATE & JOB GROUP	49
267	HILL & SMITH	27
268	HOLLAS GROUP	50
269	HOLLIS BROS & E.S.A.	17
270	HOMFRAY & CO	37
271	HOOVER	39
272	HOPKINSONS HLDGS	24
273	HOUSE OF LEROSE	59
274	HOVERINGHAM GROUP	14
275	HOWARD MACHINERY	27
276	HUNT & MOSCROP (MIDDLETON)	22
277	ICL	19
278	IMPERIAL CHEMICAL INDUSTRIES	68
279	IMPERIAL COGT GAS ASSOC	70
280	IMPERIAL METAL INDUSTRIES	32
281	INTERNATIONAL COMBUSTION (HLDGS)	26
282	INTERNATIONAL PAINT CO	16
283	INVERESK GROUP	54
284	J.B. HLDGS	14
285	JACKSON (J. & H.B.)	27
286	JENTIQUE HLDGS	38
287	JEROME (S.) & SONS (HLDGS)	61
288	JOHNSON & FIRTH BROWN	33
289	JOHNSON, MATTHEY & CO	32
290	JOHNSON-RICHARDS (H. & R.) TILES	14
291	JONES (A.A.) & SHIPMAN	28
292	JUDGE INTERNATIONAL	42

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293	K SHOES	64
294	KALAMAZOO	69
295	KAYSER BONDOR	59
296	KELSEY INDUSTRIES	35
297	KLEEMAN INDUSTRIAL HLDGS	27
298	LADIES PRIDE OUTERWEAR	59
299	LAFARGE ORGANISATION	15
300	LAIRD GROUP	27
301	LAKE & ELLIOT	21
302	LAMBERT HOWARTH GROUP	64
303	LAMSON INDUSTRIES	69
304	LANKRO CHEMICALS GROUP	68
305	LAPORTE INDUSTRIES (HLDGS)	68
306	LE BAS (EDWARD)	22
307	LEAD INDUSTRIES GROUP	32
308	LEBUS (HARRIS)	38
309	LEC REFRIGERATION	39
310	LEE (ARTHUR) & SONS	33
311	LEE COOPER GROUP	59
312	LEIGH MILLS CO	61
313	LESNEY PRODUCTS & CO	65
314	LEY'S FOUNDRIES & ENGINEERING	21
315	LEYLAND PAINT & WALLPAPER	16
316	LIGHTING & LEISURE INDUSTRIES	19
317	LINCROFT KILGOUR GROUP	59
318	LINDUSTRIES	73
319	LINER CONCRETE MACHINERY CO	22
320	LINREAD	27
321	LLOYD (F.H.) HLDGS	27
322	LOCKER (THOMAS) (HLDGS)	26
323	LONDON BRICK CO	12
324	LONDON & MIDLAND INDUSTRIALS	73
325	LONG & HAMBLY	66
326	LONSDALE UNIVERSAL	73
327	LOW & BONAR GROUP	73
328	LUCAS INDUSTRIES	41
329	LYONS (J.) & CO	49
330	M.K. ELECTRIC HLDGS	19
331	M.K. REFRIGERATION	30
332	MCCLEERY L'AMIE GROUP	73
333	MACKAY (HUGH) & CO	37
334	MCKECHNIE BROS	32
335	MACLELLAN (P. & W.)	27
336	MCNEILL GROUP	13
337	MACPHERSON (DONALD) GROUP	16
338	HANDERS (HLDGS)	16
339	MANGANESE-BRONZE HLDGS	32
340	MARLEY	14
341	MARSHALL (THOMAS) & CO (LOXLEY)	25
342	MARTIN (ALBERT) HLDGS	59
343	MARTIN-BLACK	26
344	MARTONAIR INTERNATIONAL	24
345	MATTHEWS (BERNARD)	43
346	MEDMINSTER	56
347	MENTMORE MANUFACTURING CO	69
348	METAL BOX	54
349	METAL CLOSURES GROUP	54
350	METALRAX (HLDGS)	27
351	METTOY CO	65
352	MIDLAND INDUSTRIES	27
353	MINING SUPPLIES	22
354	MITCHELL, SOMERS	21
355	MIXCONCRETE (HLDGS)	15
356	MONO CONTAINERS	54

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357	HONTFORT (KNITTING MILLS)	59
358	MORGAN CRUCIBLE CO	73
359	MORRIS (HERBERT)	23
360	MOSS ENGINEERING GROUP	27
361	MOSS (ROBERT)	66
362	MUIRHEAD	19
363	MYSON GROUP	30
364	NATIONAL CARBONISING CO	72
365	NEEDLERS	49
366	NEIL & SPENCER HLDGS	22
367	NEILL (JAMES) HLDGS	28
368	NEWBOLD & BURTON HLDGS	64
369	NEWBY GROUP	27
370	NEWMAN INDUSTRIES	19
371	NEWMAN-TONKS	14
372	NEWHAMS TUBES	27
373	NOBLE & LUND	28
374	NORCROS	73
375	NORTH BRITISH STEEL GROUP (HLDGS)	21
376	NORTHERN FOODS	51
377	NORVIC SECURITIES	64
378	NOTTINGHAM MANUFACTURING CO	59
379	NU-SWIFT INDUSTRIES	76
380	OFREX GROUP	69
381	OLYMPIA (REDACRE)	62
382	OSBORN (SAMUEL) & CO	33
383	PARKER-KNOLL	38
384	PARKLAND TEXTILE (HLDGS)	61
385	PATERSON (R.) & SONS	49
386	PAULS & WHITES	49
387	PEARSON (S.) & SON	73
388	PEGLER-HATTERSLEY	24
389	PENTOS	73
390	PETBOW HLDGS	19
391	PHILLIPS PATENTS (HLDGS)	64
392	PICKLES (WILLIAM) & CO	62
393	PILKINGTON BROS	14
394	PITTARD GROUP	59
395	PLAXTON'S (SCARBOROUGH)	43
396	PLESSEY CO	19
397	PORK FARMS	49
398	PORTALS HLDGS	73
399	POWELL-DUFFRYN	73
400	PRATT (F.) ENGINEERING CORP	27
401	PRESTIGE GROUP	40
402	PYE HLDGS	35
403	RACAL ELECTRONICS	35
404	RAINE ENGINEERING INDUSTRIES	27
405	RANDALL (J. & L.)	65
406	RANK ORGANISATION	69
407	RANKS HOVIS MCDUGALL	50
408	RANSOME HOFFMANN POLLARD	27
409	RANSOMES SIMS & JEFFERIES	27
410	RATCLIFFS (GREAT BRIDGE)	32
411	RCF HLDGS	28
412	READICUT INTERNATIONAL	37
413	READY MIXED CONCRETE	15
414	RECKITT & COLMAN	67
415	RECORD RIDGWAY	26
416	REDFEARN NATIONAL GLASS	54
417	REDMAN HEENAN INTERNATIONAL	27
418	REED INTERNATIONAL	73
419	REED & SMITH HLDGS	54
420	RENOLD	27

421	RENTOKIL GROUP	68
422	REVERTEX CHEMICALS	68
423	REXMORE	62
424	REYROLLE PARSONS	19
425	RICHARDS	60
426	RICHARDSON WESTGARTH & CO	22
427	ROBERTSON FOODS	49
428	ROCKWARE GROUP	54
429	ROPNER HLDGS	73
430	ROTAFLEX(GB)	19
431	ROTAPRINT	69
432	ROTORK	24
433	ROWAN & BODEN	73
434	ROWNTREE HACKINTOSH	49
435	ROYAL SOVEREIGN GROUP	69
436	ROYAL WORCESTER	73
437	RUBEROID	14
438	RUGBY PORTLAND CEMENT CO	15
439	SALE TILNEY & CO	73
440	SANDERSON KAYSER	33
441	SANDERSON MURRAY & ELDER(HLDGS)	61
442	SAYERS(CONFECTIONERS)	50
443	SCAPA GROUP	62
444	SCHOLES(GEORGE H.) & CO	19
445	SCOTT & ROBERTSON	62
446	SCOTTISH AGRICULTURAL INDUSTRIES	68
447	SCOTTISH & UNIVERSAL INVESTMENTS	73
448	SELINCOURT	59
449	SENIOR ENGINEERING GROUP	27
450	SERCK	27
451	SHAW CARPETS	37
452	SHAW(FRANCIS) & CO	22
453	SHEEPBRIDGE ENGINEERING	27
454	SHILOH SPINNERS	62
455	SIDLAW INDUSTRIES	62
456	SIEBE GORMAN HLDGS	76
457	SILENTNIGHT HLDGS	38
458	SILHOUETTE(LONDON)	59
459	SILKOLENE LUBRICANTS	70
460	SIMON ENGINEERING	22
461	SIMPSON(S.)	59
462	SINDALL(WILLIAM)	62
463	SIRDAR	61
464	600 GROUP	27
465	SMITH(DAVID S.)(HLDGS)	54
466	SMITH & NEPHEW ASSOCIATED COS	67
467	SMITHS INDUSTRIES	27
468	SOLICITORS' LAW STATIONERY SOCIETY	73
469	SPEAR & JACKSON-INTERNATIONAL	28
470	SPENCER GEARS(HLDGS)	27
471	SPENCER(GEORGE)	59
472	SPILLERS	50
473	SPIRAX-SARCO ENGINEERING	24
474	SPOONER INDUSTRIES	22
475	SQUIRREL HORN	49
476	STAFFORDSHIRE POTTERIES(HLDGS)	40
477	STAFLEX INTERNATIONAL	59
478	STANDARD FIREWORKS	66
479	STAVELEY INDUSTRIES	73
480	STEETLEY CO	73
481	STONE-PLATT INDUSTRIES	22
482	STONEHILL HLDGS	38
483	STOREY BROS & CO	66
484	STOTHERT & PITT	23

485	STROOD-RILEY DRUMMOND	62
486	SUMNER(FRANCIS)(HLDGS)	73
487	SUMRIE-CLOTHES	59
488	SUTCLIFFE,SPEAKMAN & CO	22
489	T.P.T. ¹	54
490	TACE	27
491	TALBEX GROUP	73
492	TARMAC	14
493	TATE & LYLE	49
494	TECALEMIT	41
495	TELEPHONE RENTALS	69
496	TERN-CONSULATE	59
497	THERMAL-SYNDICATE	25
498	THORN ELECTRICAL INDUSTRIES	35
499	TOMKINSONS(HLDGS)	37
500	TOOTAL	62
501	TOWLES	59
502	TRAFFORD CARPETS(HLDGS)	37
503	TRANSPARENT-PAPER	54
504	TRICENTROL	70
505	TRIEFUS & CO	28
506	TRIPLEX-FOUNDRIES GROUP	21
507	TUBE INVESTMENTS	27
508	TUNNEL HLDGS	15
509	TURNER-MANUFACTURING CO ¹	41
510	TURNER & NEWALL	73
511	UKO INTERNATIONAL	31
512	ULTRAMAR CO	70
513	UNICORN INDUSTRIES	27
514	UNILEVER	49
515	UNITED-BISCUITS(HLDGS)	56
516	UNITED ENGINEERING INDUSTRIES	73
517	UNITED GAS INDUSTRIES	27
518	UNITED-SPRING & STEEL GROUP	27
519	UNITED WIRE GROUP	26
520	UNOCHROME INTERNATIONAL	27
521	VALOR CO	39
522	VANTONA GROUP	62
523	VICKERS	27
524	VICTORIA CARPET HLDGS	37
525	VINCENT(HARRY) ²	49
526	VINERS	40
527	VISCOSE DEVELOPMENT CO	68
528	WADDINGTON(JOHN)	54
529	WADE POTTERIES	40
530	WADKIN	28
531	WALKER(C & W)HLDGS	25
532	WARD & GOLDSTONE	19
533	WARD(THOS.W.)	27
534	WARD WHITE GROUP	64
535	WARDLE(BERNARD)& CO	66
536	WARNE WRIGHT & ROWLAND	27
537	HARREN(JAMES)& CO ¹	73
538	WATTS,BLAKE,BEARNE & CO	76
539	WEDGWOOD	40
540	WEIR GROUP	27
541	WELLMAN ENGINEERING CORP	25
542	WESTBRICK PRODUCTS	12
543	WESTINGHOUSE BRAKE & SIGNAL CO	19
544	WESTLAND AIRCRAFT	11
545	WESTON-EVANS GROUP	22
546	WETTERN BROS	14
547	WEYBURN ENGINEERING CO ¹	27
548	WHESSOE	25

549	WHILEY (GEORGE M.) ¹	76
550	WHITECROFT	73
551	WHITELEY (B.S. & L.)	54
552	WILKES (JAMES)	69
553	WILKINSON MATCH	73
554	WILLIAMS (JOHN) OF CARDIFF	33
555	WILLOKS FRANCIS	67
556	WILMOT-BREEDEN (HLDGS)	41
557	WINN INDUSTRIES	73
558	WITTER (THOMAS) & CO	37
559	WOLF ELECTRIC TOOLS (HLDGS)	28
560	WOLSTENHOLME BRONZE POWDERS	32
561	WOLVERHAMPTON DIE CASTING GROUP ¹	32
562	WOOD EASTON HLDGS ¹	59
563	WOOD HALL TRUST	73
564	WOODHEAD (JONAS) & SONS	41
565	WOODHOUSE & RIXSON (HLDGS)	27
566	WORMALDS, WALKER & ATKINSON	61
567	WORTH (BOND) HLDGS ¹	37
568	WRIGHTON (F.) & SONS (ASSOCIATED COS)	38
569	YORK TRAILER HOLDINGS	43
570	YORKSHIRE CHEMICALS	68

Appendix 5.2 (contd)

List of Firms in the 14-Industry Manufacturing Sample

No.	G	Name of Firm	SEIG Code
1	2	A.E. ELECTRONIC COMPONENTS	35
2	2	A.P.V. HLDGS	22
3	1	ALRIGHT & WILSON	68
4	3	ALLEBONE & SONS	64
5	2	ALLIED INSULATORS	19
6	3	ALLIED TEXTILE COMPANIES	61
7	1	ALPINE HLDGS	14
8	1	ANCHOR CHEMICAL CO	68
9	2	ANDERSON STRATHCLYDE	22
10	1	ARMITAGE SHANKS GROUP	14
11	2	ARMSTRONG EQUIPMENT	41
12	1	ASH & LACY	32
13	2	ASSOCIATED ENGINEERING	41
14	1	ASSOCIATED PAPER INDUSTRIES	54
15	3	ATKINS BROS (HOSIERY)	59
16	2	AUTOMOTIVE PRODUCTS	41
17	2	AVON RUBBER CO	41
18	3	BAIRD (WILLIAM) & CO	59
19	2	BAKER PERKINS HLDGS	22
20	1	BANRO CONSOLIDATED INDUSTRIES	32
21	4	BARR (A.G.) & CO	49

2	22	3	BARROW HEPBURN GROUP	64
3	23	4	BASSETT(GEO.) HLDGS	49
4	24	2	BBA GROUP	41
5	25	3	BEALES(JOHN) ASSOCIATED COMPANIES	59
6	26	1	BEATSON, CLARK & CO	54
7	27	1	BEMROSE CORP	54
8	28	2	BENFORD CONCRETE MACHINERY	22
9	29	4	BIBBY(J.) & SONS	49
10	30	2	BICC	19
11	31	1	BIRMINGHAM MINT	32
12	32	3	BLACKMAN & CONRAD	59
13	33	1	BLAGDEN & NOAKES(HLDGS)	54
14	34	2	BLUEMEL BROS	41
15	35	1	BCC INT	68
16	36	3	BODYCOTE INTERNATIONAL	62
17	37	3	BOND STREET FABRICS	62
18	38	2	BOULTON(WILLIAM) GROUP	22
19	39	2	BOWTHORPE HLDGS	35
20	40	1	BPE INDUSTRIES	14
21	41	1	BRADY INDUSTRIES	14
22	42	1	BRENT CHEMICALS INTERNATIONAL	68
23	43	3	BRIGHT(JOHN) GROUP	62
24	44	1	BRITISH DREDGING CO	14
25	45	3	BRITISH MOHAIR SPINNERS	61
26	46	4	BRITISH SUGAR CORP	49
27	47	1	BRITISH TAR PRODUCTS	68
28	48	4	BRITISH VENDING INDUSTRIES	49
29	49	2	BROOKE TOOL ENGINEERING(HLDGS)	28
30	50	2	BROWN BROS CORP	41
31	51	2	BROWN(JOHN) & CO	28
32	52	2	BSR	35
33	53	2	BULGIN(A.F.) & CO	35
34	54	3	BULMER & LUMB(HLDGS)	61
35	55	1	BUNZL PULP & PAPER	54
36	56	1	BURRELL & CO	68
37	57	1	BURT BOULTON HLDGS	14
38	58	3	BURY & MASCO(HLDGS)	62
39	59	4	CADBURY SCHWEPPE	49
40	60	1	CAPE INDUSTRIES	14
41	61	1	CAPSEALS	54
42	62	1	CARLESS CAPEL & LEONARD	68
43	63	1	CARRON CO(HLDGS)	14
44	64	1	CATAEIN	68
45	65	3	CAWDAW INDUSTRIAL HLDGS	62
46	66	2	CELESTION INDUSTRIES	35
47	67	3	CHAMBERLAIN PHIPPS	64
48	68	2	CHLORIDE GROUP	19
49	69	3	CHURCH & CO	64
50	70	2	CLARKE(T.) & CO	19
51	71	2	CLAYTON DEWANDRE HLDGS	41
52	72	1	CLIFFORD(CHARLES) INDUSTRIES	32
53	73	1	COATES BROS & CO	68
54	74	3	COATS-PATONS	62
55	75	1	COHEN(A.) & CO	32
56	76	1	COLE(R.H.)	68
57	77	2	CCPAIR	22
58	78	3	COMPTON(J.) SONS & WEBB(HLDGS)	59
59	79	3	CORAH	59
60	80	1	CRODA INTERNATIONAL	68
61	81	1	CROPPER(JAMES) & CO	54
62	82	1	CROSSLEY BUILDING PRODUCTS	14
63	83	3	CROWTHER(JOHN) GROUP	61
64	84	1	CULTER GUARD BRIDGE HLDGS	54
65	85	1	DELTA METAL CO	32

3	87	2	DESOUTTER BROS(HLGS)	28
4	88	2	DEWHURST & PARTNER	19
5	89	1	DICKINSON ROBINSON GROUP	54
6	90	2	DORMAN SMITH HLGS ¹	19
7	91	2	DOWDING & MILLS	19
8	92	2	DUBILIER	19
9	93	2	DUNLOP HLGS	41
10	94	1	DURAPIPE INTERNATIONAL	14
11	95	3	EARLY(CHARLES)& MARRIOTT(WITNEY)	61
12	96	1	EAST LANCASHIRE PAPER GROUP	54
13	97	2	EDBRO(HLGS)	41
14	98	2	ELECTRONIC MACHINE CO	35
15	99	2	ELLIOTT(E.)& CO	28
16	100	3	ELLIS & GOLDSTEIN(HLGS)	59
17	101	2	ENERGY SERVICES & ELECTRONICS	35
18	102	1	EUCALYPTUS PULP MILLS	54
19	103	2	EVER READY CO(HLGS) ¹	35
20	104	1	EVERED & CO HLGS	14
21	105	1	EVODE HLGS	14
22	106	2	FAIRBAIRN LAWSON	22
23	107	2	FARNELL ELECTRONICS	35
24	108	1	FED INTERNATIONAL	68
25	109	1	FEDERATED CHEMICAL HLGS ¹	68
26	110	4	FEEDEX	49
27	111	2	FIDELITY RADIO	35
28	112	1	FISONS	68
29	113	3	FOGARTY(E.)& CO	62
30	114	1	FOSECO MINSEP	32
31	115	3	FOSTER(JOHN)& SON	61
32	116	3	FRENCH(THOMAS)& SONS	62
33	117	3	G.R.(HLGS)	62
34	118	2	GARDNER(L.)& SONS	41
35	119	3	GARNAR SCOTBLAIR	64
36	120	2	GENERAL ELECTRIC CO	19
37	121	1	GLASS & METAL HLGS	14
38	122	1	GLYNWED	14
39	123	4	GOLDREI(CH.)FOUCARD & SON	49
40	124	3	HAGGAS(JOHN)	61
41	125	2	HALLAM,SLEIGH & CHESTON	41
42	126	1	HENDERSON(P.C.)GROUP	14
43	127	1	HEPWORTH CERAMIC HLGS	14
44	128	3	HICKING PENTECOST & CO	62
45	129	1	HICKSON & WELCH(HLGS)	68
46	130	3	HIELD BROS	61
47	131	4	HIGHGATE & JOB GROUP	49
48	132	3	HOUSE OF LEROSE	59
49	133	1	HOVERINGHAM GROUP	14
50	134	2	HUNT & MOSCROP(MIDDLETON)	22
51	135	2	ICL	19
52	136	1	IMPERIAL CHEMICAL INDUSTRIES	68
53	137	1	IMPERIAL METAL INDUSTRIES	32
54	138	1	INVERESK GROUP	54
55	139	1	J.B.HLGS	14
56	140	3	JEROME(S.)& SONS(HLGS)	61
57	141	1	JOHNSON,MATTHEY & CO	32
58	142	1	JOHNSON-RICHARDS(H.&R.)TILES	14
59	143	2	JONES(A.A.)& SHIPMAN	28
60	144	3	K SHOES	64
61	145	3	KAYSER BONDOR	59
62	146	2	KELSEY INDUSTRIES	35
63	147	3	LACIES PRIDE OUTERWEAR	59
64	148	3	LAMBERT HOWARTH GROUP	64
65	149	1	LANKRO CHEMICALS GROUP ¹	68

2	150	1	LAPORTE INDUSTRIES (HLDGS)	68
3	151	2	LE BASTEDWARD	22
4	152	1	LEAD INDUSTRIES GROUP	32
5	153	3	LEE COOPER GROUP	59
6	154	3	LEIGH MILLS CO	61
7	155	2	LIGHTING & LEISURE INDUSTRIES ¹	19
8	156	3	LINGROFT KILGOUR GROUP	59
9	157	2	LINER CONCRETE MACHINERY CO ¹	22
10	158	2	LUCAS INDUSTRIES	41
11	159	4	LYONS (J.) & CO	49
12	160	2	M.K. ELECTRIC HLDGS	19
13	161	1	MCKECHNIE BROS	32
14	162	1	MANGANESE BRONZE HLDGS	32
15	163	1	MARLEY	14
16	164	3	MARTIN (ALBERT) HLDGS	59
17	165	4	MATTHEWS (BERNARD)	49
18	166	1	METAL BOX	54
19	167	1	METAL CLOSURES GROUP	54
20	168	2	MINING SUPPLIES	22
21	169	1	MONO CONTAINERS ¹	54
22	170	3	MONTFORT (KNITTING MILLS)	59
23	171	2	MUIRHEAD	19
24	172	4	NEEDLERS	49
25	173	2	NEIL & SPENCER HLDGS	22
26	174	2	NEILL (JAMES) HLDGS	28
27	175	3	NEWBOLD & BURTON HLDGS	64
28	176	2	NEWMAN INDUSTRIES	19
29	177	1	NEWMAN-TONKS	14
30	178	2	NOBLE & LUND	28
31	179	3	NORVIC SECURITIES	64
32	180	3	NOTTINGHAM MANUFACTURING CO	59
33	181	3	OLYMPIA (REDACRE)	62
34	182	3	PARKLAND TEXTILE (HLDGS)	61
35	183	4	PATERSON (R.) & SONS	49
36	184	4	PAULS & WHITES	49
37	185	2	PETBOW HLDGS	19
38	186	3	PHILLIPS PATENTS (HLDGS)	64
39	187	3	PICKLES (WILLIAM) & CO	62
40	188	1	PIEKINGTON BROS	14
41	189	3	PITTARD GROUP	59
42	190	2	PLESSEY CO	19
43	191	4	PORK FARMS ¹	49
44	192	2	PYE HLDGS	35
45	193	2	RACAL ELECTRONICS	35
46	194	1	RATCLIFFS (GREAT BRIDGE)	32
47	195	2	RCF HLDGS	28
48	196	2	RECORD RIDGWAY	28
49	197	1	REDFEARN NATIONAL GLASS	54
50	198	1	REED & SMITH HLDGS ¹	54
51	199	1	RENTOKIL GROUP	68
52	200	1	REVERTEX CHEMICALS	68
53	201	3	REXMORE	62
54	202	2	REYROLLE PARSONS ¹	19
55	203	2	RICHARDSON WESTGARTH & CO	22
56	204	4	ROBERTSON FOODS	49
57	205	1	ROCKWARE GROUP	54
58	206	2	ROTAFLEX (GB)	19
59	207	4	ROWNTREE MACKINTOSH	49
60	208	1	RUBEROID	14
61	209	3	SANDERSON MURRAY & ELDER (HLDGS)	61
62	210	3	SCAPA GROUP	62
63	211	2	SCHOLES (GEORGE H.) & CO	19
64	212	3	SCOTT & ROBERTSON	62
65	213	1	SCOTTISH AGRICULTURAL INDUSTRIES	68

2	214	3	SELINCOURT	59
3	215	2	SHAW(FRANCIS) & CO	22
4	216	3	SHILOH SPINNERS	62
5	217	3	SIDLAH INDUSTRIES	62
6	218	3	SILHOUETTE(LONDON)	59
7	219	2	SIMON ENGINEERING	22
8	220	3	SIMPSON(S.)	59
9	221	3	SINDALL(WILLIAM)	62
10	222	3	SIRDAR	61
11	223	1	SMITH(DAVID S.) (HLOGS)	54
12	224	2	SPEAR & JACKSON INTERNATIONAL	28
13	225	3	SPENCER(GEORGE)	59
14	226	2	SPOONER INDUSTRIES	22
15	227	4	SQUIRREL HORN	49
16	228	3	STAFLEX INTERNATIONAL	59
17	229	1	STANDARD FIREWORKS	68
18	230	2	STONE-PLATT INDUSTRIES	22
19	231	3	STROUD RILEY DRUMMOND	62
20	232	3	SUMRIE CLOTHES	59
21	233	2	SUTCLIFFE, SPEAKMAN & CO	22
22	234	1	T.P.T.	54
23	235	1	TARMAC	14
24	236	4	TATE & LYLE	49
25	237	2	TECALEMIT	41
26	238	3	TERN-CONSULATE	59
27	239	2	THORN ELECTRICAL INDUSTRIES	35
28	240	3	TOTAL	62
29	241	3	TOWLES	59
30	242	1	TRANSPARENT PAPER	54
31	243	2	TRIEFUS & CO	28
32	244	2	TURNER MANUFACTURING CO ¹	41
33	245	4	UNILEVER	49
34	246	3	VANTONA GROUP	62
35	247	4	VINCENT(HARRY)	49
36	248	1	VISCOSE DEVELOPMENT CO	68
37	249	1	WADDINGTON(JOHN)	54
38	250	2	WADKIN	28
39	251	2	WARD & GOLDSTONE	19
40	252	3	WARD WHITE GROUP	64
41	253	2	WESTINGHOUSE BRAKE & SIGNAL CO	19
42	254	2	WESTON-EVANS GROUP	22
43	255	1	WETTERN EROS	14
44	256	1	WHITELEY(B.S. & W.)	54
45	257	2	WILMOT-BREEDEN(HLOGS)	41
46	258	2	WOLF ELECTRIC TOOLS(HLOGS)	28
	259	1	WOLSTENHOLME BRONZE POWDERS	32
	260	1	WOLVERHAMPTON DIE CASTING GROUP ¹	32
	261	3	WOOD EASTON HLOGS ¹	59
	262	2	WOODHEAD(JONAS) & SONS	41
	263	3	WORMALDS, WALKER & ATKINSON	61
	264	1	YORKSHIRE CHEMICALS	68

Notes: 1 = the firm is not included in the 1977 sample having ceased trading owing to takeover, liquidation etc.

2 = the firm traded under a different name in 1977.

G = the group number of the firm in the 4-group discriminant analysis (see Chapter 9)

Appendix 5.3

List of Firms in the Distribution Sample

<u>No.</u>	<u>Name of Firm</u>	<u>SEIC Code</u>
1	A.A.H.	72
2	ADAMS FOODS ¹	49
3	ADAMS & GIBSON	42
4	ALEXANDERS HLDGS	42
5	ALLIED LEATHER INDUSTRIES	64
6	ALLIED RETAILERS	56
7	AMALGAMATED METAL CORP	32
8	APPLEYARD GROUP OF COMPANIES	42
9	ARLINGTON MOTOR HLDGS	42
10	ASSOCIATED DAIRIES	51
11	ATTHOOD GARAGES	42
12	AUDIOTRONIC HLDGS	58
13	B.S.G. INTERNATIONAL	41
14	BAMBERGERS	17
15	BANK BRIDGE GROUP ¹	73
16	BARKER & DOBSON	49
17	BATLEYS OF YORKSHIRE	51
18	BEATTIE (JAMES)	55
19	BECKMAN (A.)	62
20	BEJAM GROUP	51
21	BENTALLS	55
22	BISHOP'S STORES	51
23	BLACKWOOD HODGE	23
24	BOOTH (INTERNATIONAL HLDGS)	59
25	BOOTS CO	58
26	BOURNE & HOLLINGSWORTH	55
27	BRAID GROUP	42
28	BRASWAY	33
29	BREMNER & CO	55
30	BRITISH HOME STORES	58
31	BROOKE BOND LIEBIG	49
32	BROWN (N.) INVESTMENTS	57
33	BROWN & TAWSE	33
34	BROWNLEE & CO	17
35	BURTON GROUP	58
36	C.G.S.B. HLDGS	42
37	CAFFYNS	42
38	CAKEBREAD, ROBEY & CO	13
39	CAMPARI	59
40	CANTORS	56
41	CASKET (S.) (HLDGS)	59
42	CAVENHAM	51

43	CANWOODS HLDGS	72
44	CHARRINGTONS INDUSTRIAL HLDGS	72
45	CLIFFORD'S DAIRIES	51
46	COLMORE INVESTMENTS	42
47	COMBINED ENGLISH STORES GROUP	58
48	COMET RADIOVISION SERVICES	58
49	COURTS (FURNISHERS)	56
50	COWIE (T.)	42
51	CRELLON HLDGS	19
52	CULLEN'S STORES	51
53	CURRYS	58
54	DANISH BACON CO	49
55	DAVIS (GODFREY)	42
56	DEBENHAMS	55
57	DOLAN PACKAGING ¹	54
58	DORADA HLDGS	42
59	DUITON-FORSHAW GROUP	42
60	EDWARDS (LOUIS C.) & SONS (MANCHESTER)	51
61	ELECTROCOMPONENTS	35
62	ELLIS & EVERARD	13
63	EMPIRE STORES (BRADFORD)	57
64	ENGLAND (J.E.) & SONS (WELLINGTON)	51
65	ERITH & CO	13
66	EWER (GEORGE) & CO	72
67	F.M.C.	49
68	FERGUSON INDUSTRIAL HLDGS	13
69	FIRTH (G.M.) (METALS)	33
70	FITCH LOVELL	51
71	FORTNUM & MASON	55
72	FOSTER BROS CLOTHING CO	58
73	FREEMANS (LONDON S.W.3)	57
74	GATES (FRANK G.)	42
75	GATEWAY SECURITIES ¹	51
76	GIBBONS (STANLEY) INTERNATIONAL	48
77	GIEVES GROUP	58
78	GLANFIELD LAWRENCE	42
79	GOLDBERG (A.) & SONS	55
80	GOLDMAN (H.) GROUP	40
81	GRAHAM WOOD STEEL GROUP ¹	33
82	GRATTAN WAREHOUSES	57
83	GREAT UNIVERSAL STORES ¹	58
84	HANGER INVESTMENTS	42
85	HARDY & CO (FURNISHERS)	56
86	HARGREAVES GROUP	73
87	HARRISON (T.C.)	42
88	HARTWELLS GROUP	42
89	HENDERSON (J. & W.) (HLDGS)	13
90	HENDERSON-KENTON	56
91	HENLYS	42
92	HEPWORTH (J.) & SON	58
93	HERON CORPN	42
94	HILLARDS	51
95	HILTONS FOOTWEAR	64
96	HINTON (AMOS) & SONS	51
97	HOUSE OF FRASER	55
98	HUNTING GIBSON	71
99	HURST (CHARLES)	42
100	INTERNATIONAL TIMBER CORP	17
101	JESSUPS (HLDGS)	42
102	KENNING MOTOR GROUP	42
103	KWIK SAVE DISCOUNT GROUP	51
104	L.C.P. HLDGS	73
105	LATHAM (JAMES)	17
106	LEBOFF (S.) (FCBEL)	13

107	LEIGH INTERESTS	72
108	LENNONS GROUP	51
109	LEX SERVICE GROUP	42
110	LIBERTY & CO	55
111	LILLESHELL CO	33
112	LONGTON TRANSPORT HLDGS	73
113	LOOKERS	42
114	LOW(WM.) CO	51
115	LOWLAND DRAPERY HLDGS	62
116	LYON & LYON	42
117	M.F.I. WAREHOUSES	56
118	MACARTHYS PHARMACEUTICALS	67
119	MALLINSON-DENNY	17
120	MANCHESTER GARAGES ¹	42
121	MANN & OVERTON ¹	42
122	MAPEE & CO(HLDGS)	55
123	MARKS & SPENCER	58
124	MARSHALL'S UNIVERSAL	73
125	MARTIN THE NEWSAGENT	58
126	MATTHEWS HLDGS ¹	51
127	MAY & HASSELL	17
128	MAYNARDS	49
129	MEAT TRADE SUPPLIERS ¹	49
130	MENZIES(JOHN)(HLDGS)	58
131	MEYER(MONTAGUE L.)	17
132	HILLS(A.J.)(HLDGS) ¹	49
133	MONUMENT SECURITIES ¹	59
134	MORGAN EDWARDS	51
135	MORRISON(WM.) SUPERMARKETS	51
136	MOSS BROS	58
137	MOTHERCARE	58
138	NORTON(W.E.)(HLDGS)	28
139	NSS NEWSAGENTS	58
140	NURDIN & PEACOCK	51
141	OFFICE & ELECTRONIC MACHINES	69
142	OLIVER(GEORGE)(FOOTWEAR)	64
143	OWEN OWEN	55
144	PANTO(P.) & CO	58
145	PARKER TIMBER GROUP	17
146	PENNINE MOTOR GROUP ¹	42
147	PERRY(HAROLD) MOTORS	42
148	PETERBOROUGH MOTORS ¹	42
149	PHOENIX TIMBER CO	17
150	PHOTOPIA INTERNATIONAL ¹	48
151	PREEDY(ALFRED) & SONS	58
152	PRIDE & CLARKE	42
153	QUICK(H. & J.) GROUP	42
154	RANDALLS GROUP	13
155	RAYBECK	58
156	REED(AUSTIN) GROUP	58
157	RENWICK GROUP	72
158	REYNOLDS(W.J.) HLDGS	42
159	RIX(OLIVER) ¹	42
160	ROBERTS, ADLARD & CO	13
161	S & U STORES	57
162	SABAH TIMBER CO	17
163	SAINSBURY(J)	51
164	SAMUEL(H.)	58
165	SANGERS GROUP	67
166	SAVILLE GORDON(J.) GROUP	33
167	SEARS HLDGS	73
168	SHARPE & FISHER	13
169	SIMONS & CO	51
170	SMITH(W.H.) & SON(HLDGS)	58

171	SPENCER, TURNER & BOLDERO ¹	62
172	STATUS DISCOUNT	13
173	STEAD & SIMPSON	64
174	STOCKS (JOSEPH) & SONS (HLDGS)	51
175	STYLO SHOES	64
176	TATE OF LEEDS	42
177	TELEFUSION	36
178	TESCO STORES (HLDGS)	51
179	TILLING (THOMAS)	73
180	TIME PRODUCTS	58
181	TRAVIS & ARNOLD	13
182	TURNER (W. & E.)	58
183	UBM GROUP	13
184	UDS GROUP	58
185	UNIGATE	51
186	UPTON (E.) & SONS	55
187	WADES DEPARTMENTAL STORES	55
188	WADHAM STRINGER	42
189	WALKER (J. O.) & CO	17
190	WALKER (JAMES) GOLDSMITH & SILVERSMITH	58
191	WARING & GILLOW (HLDGS)	56
192	WATSON & PHILIP	51
193	WESTERN MOTOR HLDGS	42
194	WHEATSHEAF DISTRIBUTION & TRADING	51
195	WHOLESALE FITTINGS CO	19
196	WIGFALL (HENRY) & SON	36
197	WILKINSON WARBURTON	62
198	WILLIAMS HUDSON GROUP ¹	73
199	WOLSELEY-HUGHES	30
200	WOOD (S. W.) GROUP	32
201	WOOLWORTH (F. W.) & CO	58

Notes: 1 = the firm is not included in the 1977 sample having ceased trading owing to takeover, liquidation etc.

The 1977 sample includes 10 new firms not in the earlier samples.

Appendix 5.4

Financial Ratios Included in the Database¹

Total Assets	CF/S	COS/AINV
TNW	CF/ATA	AQA/PDOE
TCE	CF/ATL	AQA/S
NCE	CF/ACL	ACA/S
Sales	CF/ATCE	S/AFA
FF/S	CF/ANCE	S/ATA
FF/ATCE	OSCF/AOSE	S/ATCE
FF/ATA	Dr/CA	S/ANCE
VA/S	Dr/INV	S/AINV
VA/ATA	CA/CL	Days Drs
VA/ATCE	FA/TA	QA/CL
VA/ANCE	WC/TNW	QA/TL
EBIT/S	WC/TL	WC/IEV
EBIT/ATA	TA/ER	INV/CA
EBIT/ATCE	WC/NCE *	(QA-CL)/PDOE
VA/ER	WC/Dr	DIV/OSL
PBT/S	ANC/S	DIV/OSNI
PBT/ATA	TL/TNW	CL/TA
PBT/ATNW	TL/TA	QA/TA
PBT/ATL	DEBT/QA	CA/TA
PBT/ACL	EBIT/ATL	DEBT/TA
PBT/ATCE	TA/TNW	DEBT/CA
PBT/ANCEZ	QA/TNW	TNI/ATNW
TNI/S	CA/TNW	INT/EBIT
TNI/ATA	CL/TNW	Dr/Cr
NI/ANW	ATNW/S	CL/Cr
TNI/ATL	DEBT/TNW	INV/CL
TNI/ACL	DEBT/TCE	
TNI/ATCE	CA/TL	
TNI/ANCE	ACr/COS	

Notes: 1) The first five are absolute size measures but for convenience referred to as ratios.

2) See Appendix 5.5 for definition of the ratio components.

Appendix 5.5

Definitions of Ratio Components

CA	Current assets
CF	Cash flow (retained profit plus depreciation, minority interests and deferred tax less capitalised costs)
CL	Current liabilities
COS	Cost of sales
Cr	Creditors
Days Drs	(Debtors/sales) X 365 days
DEBT	Total interest bearing borrowings and loans
DIV	Dividends (ordinary shareholders' dividends)
Dr	Debtors
EBIT	Earnings before interest and tax
ER	Employees' remuneration including directors'
FA	Fixed assets excluding goodwill and intangibles
FF	Funds flow (gross trading profit)
INT	Interest
INV	Inventory (stocks and work in progress)
NCE	Net capital employed (total networth plus all long term debt and liabilities excluding intangibles)
NI	Net income (profit distributable to shareholders)
NW	Net worth (Ordinary and preference shareholders' capital plus deferred tax excluding intangibles and minority interests)
OSCF	Ordinary shareholders' cash flow (retained profits including minority interests plus depreciation, deferred tax less any capitalised costs)
OSE	Ordinary shareholders' equity (excludes preference shares but includes deferred tax, intangible assets adjustment and market value of assets adjustment)
OSE1	OSE at start of year
OSNI	Net income less preference dividend
PBT	Profit before tax
PDOE	Projected daily operating expenditure ($= \frac{\text{COS}}{365}$)
QA	Quick Assets
S	Sales

contd.-

Appendix 5.5 (contd)

TA	Total assets
TCE	Total capital employed (NCE plus non-trading liabilities)
TL	All external liabilities (does not include minority interests)
TNI	Total net income (NI plus minority interests' share of distributable income)
TNW	Total net worth (NW + minority interests)
VA	Value added (FF + ER)
WC	Working capital (CA - CL)

Notes: 'A' preceding an item denotes average between two successive years e.g. ACA - average current assets.

See paragraph 5.2.7 on the adjustments made in the computation of some of the above items.

The components of the various items listed above are shown in the following standardised profit & loss account and balance sheet.

Appendix 5.5 (contd)

THE STANDARDISED PROFIT AND LOSS ACCOUNT

ABREVI-
ATION

S	<u>SALES</u>
-	Less:Bought in Services
VA	<u>VALUE ADDED</u>
-	Less:Directors & Employees Remuneration
FF	<u>FUNDS FLOW (Trading Profit)</u>
-	Less:Depreciation
-	Associated Companies Profits
-	Other Income
EBIT	<u>EARNINGS BEFORE INTEREST & TAX</u>
INT	Less:Total Interest
PBT	<u>PROFIT BEFORE TAX</u>
-	Less:Deferred Tax
-	All Other Tax
-	<u>PROFIT AFTER TAX</u>
-	Less:Minority Interest
NI	<u>NET INCOME</u>
-	Less:Preference Dividend
DIV	Equity Dividend
	<u>RETAINED PROFITS</u>
	(Note:Capitalised Costs)

XXX				
XX	) +			
XXX				
XX	) +			
XXX				
XX	) +			
XX				
XX				
XX				
XXX				
XX				
XX				
XXX	) +			
XX				
XXX				
XX	) +			
XX				
XXX	) +			
(XX)	) -			

COS = cost of sales.
 OSNI = ordinary shareholders' net income.
 TNI = total net income,i.e.includes minority interests.

Appendix 5.5 (contd)

THE STANDARDISED BALANCE SHEETTHE ASSETS EMPLOYEDABREVIATION

		£	£
	<u>FIXED ASSETS</u>		
-	Property	XX	
-	Less: Depreciation	XX	XXX
-	Other fixed assets	XX	
-	Less: Depreciation	XX	XXX
FA	<u>NET FIXED ASSETS</u>		XXX
	<u>OTHER ASSETS</u>		
-	Associated companies	XX	
-	Unquoted investments at		
-	directors valuation	XX	
-	Inter-group accounts (non-current)	XX	
-	Other assets	XX	XXX
	<u>CURRENT ASSETS</u>		
INV	Stocks & W.I.P.	XX	
DR	Debtors & bills receivable	XX	
-	Quoted investments at market value	XX	
-	Short term investments	XX	
CASH	Cash (net of overdraft)	XX	
-	Inter-group accounts (current)	XX	
-	Other current assets	XX	
CA	<u>TOTAL CURRENT ASSETS</u>		XXX
TA	<u>TOTAL ASSETS EMPLOYED</u>		XXXX

QUICK
ASSETS

Appendix 5.5 (contd)

		<u>THE FUNDS EMPLOYED</u>			
<u>ABREVI</u>	<u>ATION</u>				
		<u>SHAREHOLDERS' EQUITY</u>	£	£	
		Preference share capital	XX		
-		Ordinary share capital	XX		
-		Reserves	XX		
-		Deferred tax	XX		
-		Intangible assets	(XX)		
-		Market value of investments adj.	XX		
NW		<u>NET WORTH</u>		XXX	
		<u>EXTERNAL FINANCE</u>			
-		Minority interests	XX		
-		Debentures (parent & subsidiary)	XX		
-		Loan stock (parent & subsidiary)	XX		
-		Government grants	XX		
-		Bank & other loans	XX		
-		Inter-group accounts (non-current)	XX		
-		Provisions	XX		
-		Deferred & other liabilities	XX		
-		<u>TOTAL LONG TERM DEBT</u>		XXX	
OVDT		Bank overdraft (net of cash)	XX		
MTF		Medium term finance	XX		
-		Short term finance & acceptance credits	XX		
CR		Creditors & bills payable	XX		
-		Current & non-current tax	XX		
-		Proposed dividend	XX		
-		Inter-group accounts (current)	XX		
-		Other current liabilities	XX		
		<u>TOTAL CURRENT LIABILITIES</u>		XXX	
		<u>TOTAL FUNDS EMPLOYED</u>		XXXX	

Note: O.S.E. = ordinary shareholders' equity.

Appendix 5.6

Concept and Mathematical Formulation

Pearson's Formulation of Spurious Correlation: In Karl Pearson's pioneering work (1897) the starting point was the zero order correlation between two variables (the undeflated variables). He compared this correlation with that between the ratios derived from the variables by deflating them with a common deflator. Thus Pearson's definition of spurious ratio correlation is the difference between the simple correlation of the undeflated variables and the correlation between ratios formed by deflating them.

He derived the following approximate relation for ratio correlation

$$P = \frac{r_{xy} V_x V_y - r_{xz} V_x V_z - r_{yz} V_y V_z + V_z^2}{(V_x^2 + V_z^2 - 2 r_{xz} V_x V_z)^{\frac{1}{2}} (V_y^2 + V_z^2 - 2 r_{yz} V_y V_z)^{\frac{1}{2}}} \quad (5A.1)$$

where

P = the simple or zero order correlation between the ratios $\frac{x}{z}$ and $\frac{y}{z}$ (hereafter referred to as the ratio correlation, or $r_{\frac{x}{z}, \frac{y}{z}}$),

x, y = the variables to be deflated,

z = the deflator,

V_x, V_y, V_z = the coefficients of variation for x, y and z respectively,

r_{xy}, r_{xz}, r_{yz} = the simple or zero order correlation coefficients.

In deriving the above expression Pearson assumed that the coefficients of variation were small and also that

$$V_x = V_y = V_z \quad \text{and} \quad r_{xz} = r_{yz} = r'.$$

From 5A.1 he derived the following result:

$$\begin{aligned} P &= .5 \left(\frac{1 + r_{xy} - 2 r'}{1 - r'} \right) \\ &= .5 + .5 \left(\frac{r_{xy} - r'}{1 - r'} \right) \end{aligned} \quad (5A.2)$$

In this formulation when $r_{xy} = 0$, $P \neq 0$. Pearson used this result to demonstrate what he regarded as the spurious nature of ratio correlation. Kuh and Meyer (1955) (hereafter, KM) regarded the first assumption of equality of coefficients of variation as too restrictive and, therefore substituted the following one, viz.

$$V_z = a V_x = a V_y$$

and obtained the relation

$$P = \frac{r_{xy} + a^2 - 2ar'}{1 + a^2 - 2r'} \quad (5A.3)$$

Depending on the values of a and r' the ratio correlation P can be greater or smaller than or equal to the simple correlation between the undeflated variables. Thus from 5A.3 it can be seen that ratio correlation can be spuriously high as well as spuriously low in relation to the simple correlation.

KM's Formulation of Spurious Correlation

Pearson's definition of spurious ratio correlation is conceptually weak. The aim of deflation is to remove the effect of the deflator and the ratio correlation must, therefore, be compared to the residual correlation of the undeflated variables after allowing for the influence of the deflator. A measure of such residual correlation is the partial correlation of the undeflated variables holding the effect of the deflator constant. It is, therefore, more appropriate to compare the ratio correlation with the partial correlation. In an important conceptual departure from the Pearsonian definition of spurious ratio correlation KM attempted to derive the conditions under which ratio correlation would be an unbiased estimate of the partial correlation, $r_{xy.z}$ with the effect of the deflator kept constant.

The conceptual weakness of the Pearsonian definition is also apparent if we consider the partial correlation when the undeflated variables are uncorrelated, that is, when $r_{xy} = 0$. It was this condition which Pearson used to demonstrate the spurious nature of ratio correlation as indicated above. But under this condition even the partial correlation $r_{xy.z}$ is not zero. Even though the undeflated series are uncorrelated when the influence of the deflator is removed there might still be some residual correlation. This can be seen by substituting $r_{xy} = 0$ in the following expression for partial correlation,

$$r_{xy.z} = \frac{r_{xy} - r_{xz} r_{yz}}{(1 - r_{xz}^2)^{\frac{1}{2}} (1 - r_{yz}^2)^{\frac{1}{2}}} \quad (5A.4)$$

The partial correlation does not reduce to zero. Applying the Pearsonian logic even the partial correlation is 'spurious' with respect to the simple correlation.

Thus residual correlation after allowing for the effect of the deflator need not be zero when the undeflated series are uncorrelated. Since it is this residual correlation which ratio correlation is intended to approximate the latter need ~~not~~ be zero when the undeflated series are uncorrelated and a non-zero ratio correlation does not necessarily constitute spurious correlation. Therefore, in order to test for spurious correlation we must compare the ratio correlation with the partial correlation and not with the simple correlation.

Conditions for Non-spurious Ratio Correlation : KM derived the conditions for the equality of ratio and partial correlations on the basis of the assumption that V_z is small (see KM for the derivation). They showed that the ratio correlation would equal the partial correlation when the equality

$$V_z = r_{xz} V_x = r_{yz} V_y \quad (5A.5)$$

is satisfied. They also showed that the necessary and sufficient condition for this equality to hold was that each of the undeflated variables be a linear homogeneous function of the deflating variable. Algebraically, the relationship between the undeflated variables and the deflator must be of the form

$$x = b_1 z + e_1 \quad \text{and} \quad y = b_2 z + e_2 \quad (5A.6)$$

where b_1 and b_2 are regression coefficients and e_1 and e_2 are stochastic error terms independent of z . Under this linear homogeneity condition the ratio correlation will be a non-spurious and unbiased estimate of the partial correlation.

Effect of Deviations from Homogeneity : Deviations from homogeneity will lead to greater or smaller bias depending on the relative importance of the correlation between the numerators and the correlation between each of the numerators and the deflator. In other words bias will be determined by the relative strength of relationship between the numerators compared to the influence of the deflator on either of them. If the influence of the deflator is small and " the coefficients of variation are not too large the ratio correlation will differ little from the correct partial correlation value while if it is large the difference between the two correlation estimates is likely to be large". (KM,p406).

Effect of Extreme Values and Heteroscedasticity : Heteroscedastic error terms in regression equations have much greater dispersion functionally related to the independent variable. Since correlation estimates are sensitive to large values they are likely to be inflated by the presence of heteroscedasticity. This is true of partial correlation estimates as well since partial correlation equals the correlation between the error terms (Koutsoyiannis,1977,p133). From 5A.6,

$$r_{xy.z} = r_{e_1.e_2}, \text{ the correlation between the error terms (5A.7)}$$

If both error terms have a similar a pattern of heteroscedasticity (as exhibited by our data;see the scattergrams in Appendix 5.7) the partial correlation is likely to be higher than when the error terms are homoscedastic.

Deflation is a means of correcting for at least some forms of heteroscedasticity the reasoning being that it removes the functional dependence of error variance on the deflator and makes error variance constant thus rendering the use of least squares regression valid (see Koutsoyiannis,1977,pp.181-96). A consequence of deflation is that large values of the dependent variable and,therefore,of the error variable are weighted down. As a result correlation between

the deflated error terms will be less than that between the undeflated error terms. On deflation 5A.6 becomes

$$\frac{x}{z} = b_1 + \frac{e_1}{z} \quad (5A.8)$$

and
$$\frac{y}{z} = b_2 + \frac{e_2}{z}$$

The ratio correlation now is

$$r_{\frac{x}{z}, \frac{y}{z}} = r_{\frac{e_1}{z}, \frac{e_2}{z}} \quad (5A.9)$$

Comparing 5A.7 and 5A.9 we see that the partial correlation is a function of the undeflated error terms and, therefore, subject to the damaging influence of extreme values whereas ratio correlation being a function of the deflated error terms is less sensitive to extreme values. KM suggest that even when the zero -intercept assumption is not met " while the ratio correlations...may not be equal to those obtainable from the undeflated data, this may not be entirely undesirable if the absolute results are subject to the damaging influence of heteroscedasticity and extreme values " (p412).

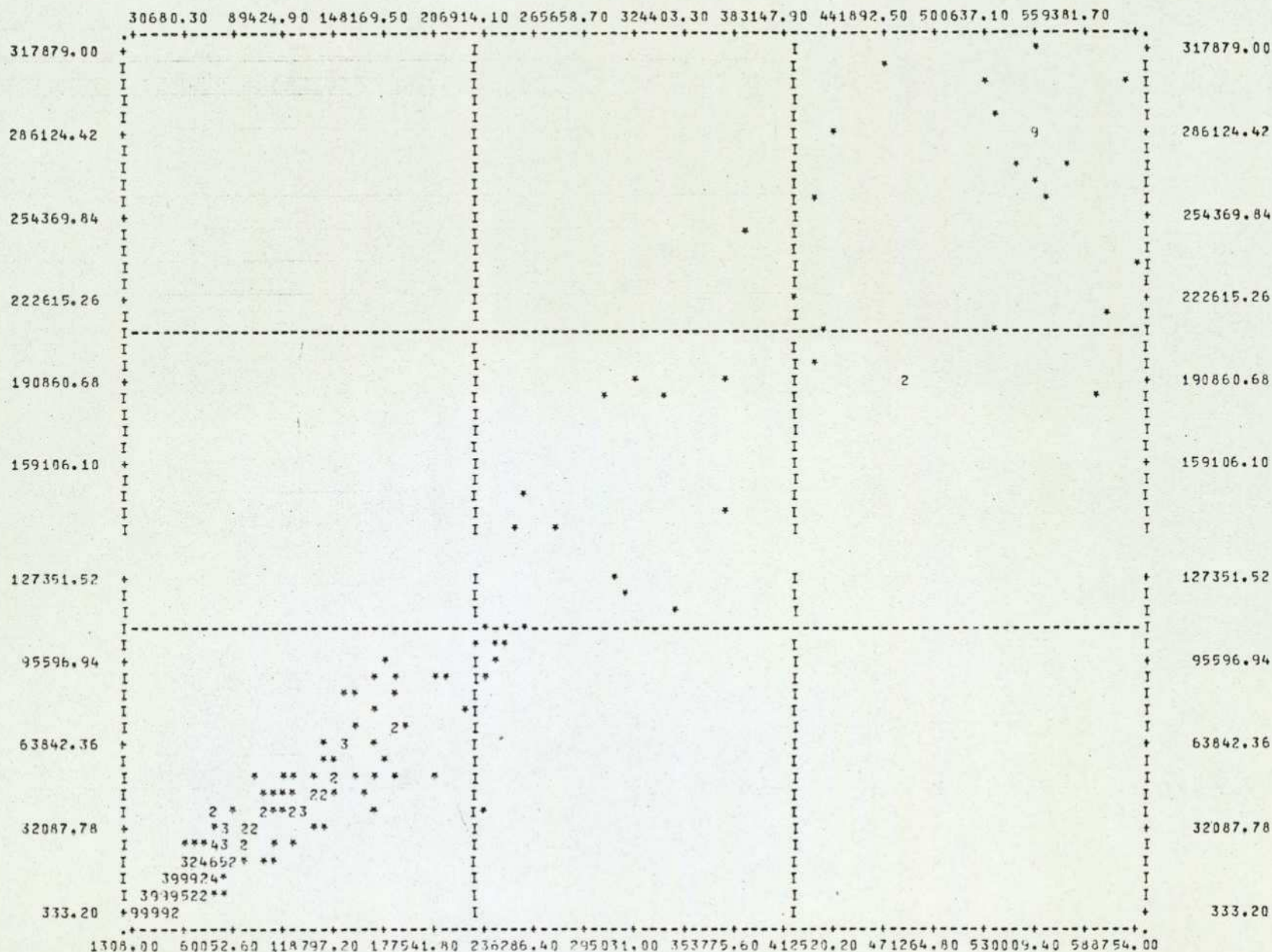
Combined Effect of Non-homogeneity and Heteroscedasticity : These two factors could cause ratio correlation estimates to differ from the corresponding partial correlations in opposing directions and in different degrees. The effect of one factor could either reinforce or reverse the distortion caused by the other factor. This interaction of the effects of the two factors might explain the odd mixture of results that we have obtained. For example, among the numerator variables only EBIT is homogeneously related to NCE and none to TCE (see Table 5.2). Yet analysis of ratio and partial correlations using these two variables as deflators indicates that in 11 out 30 cases ratio correlation is higher than partial correlation (see Tables 5.5 and 5.6), while in the other cases it is lower.

In the case of ratio pairs in which both numerators are non-homogeneous we might expect ratio correlation to be higher than partial correlation owing to the bias caused by the intercept terms. Yet, this is not true in the case of the ratio pairs CA/NCE vs QA/NCE and CA/TCE vs QA/TCE which are the most striking examples of non-homogeneous

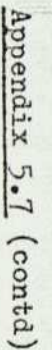
numerators (see Table 5.2). This and the other results of our analysis could, therefore, be explained only in terms of the interaction between the two factors discussed above.

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SPURIOUS CORRELATION ANALYSIS

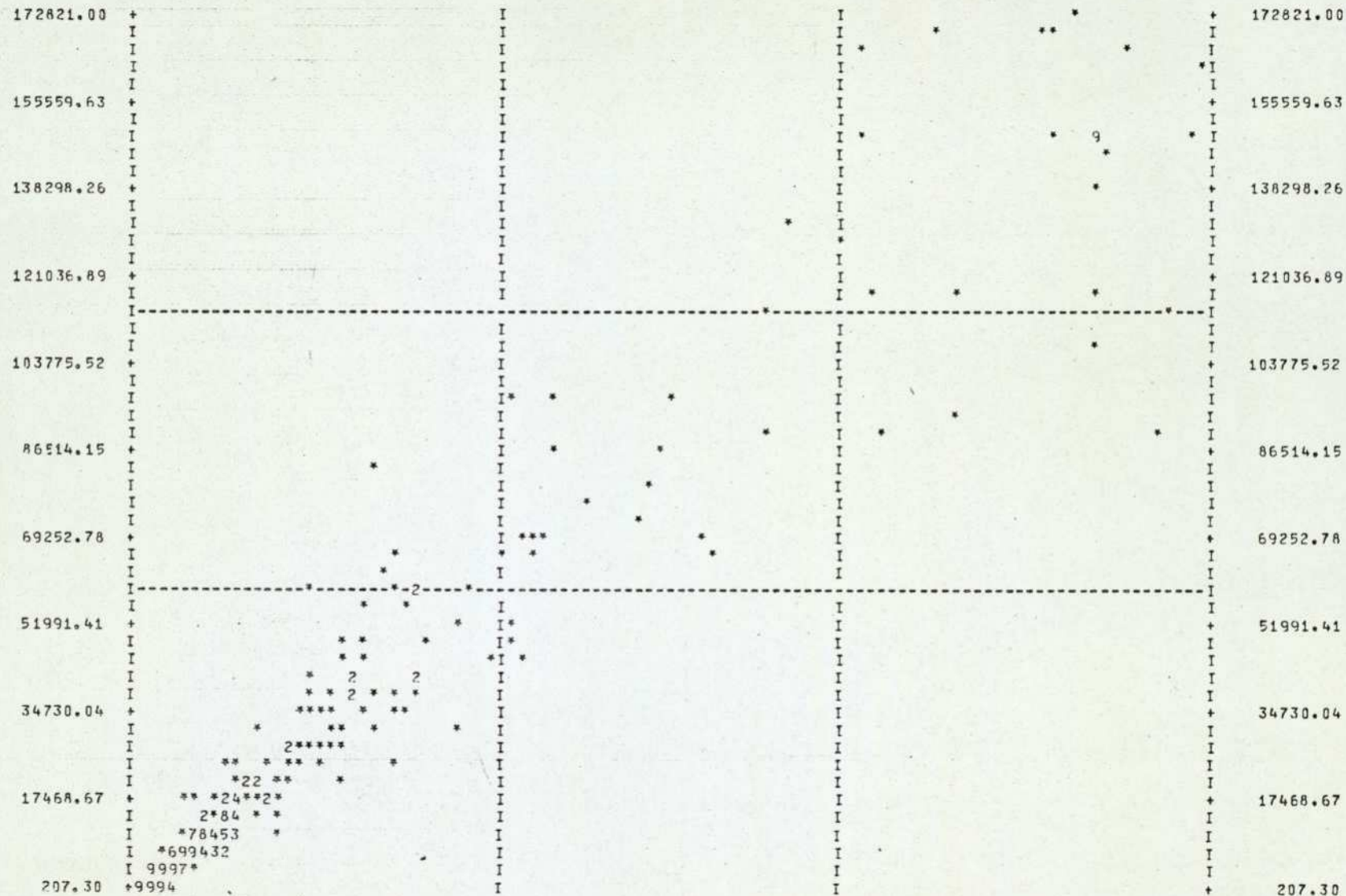
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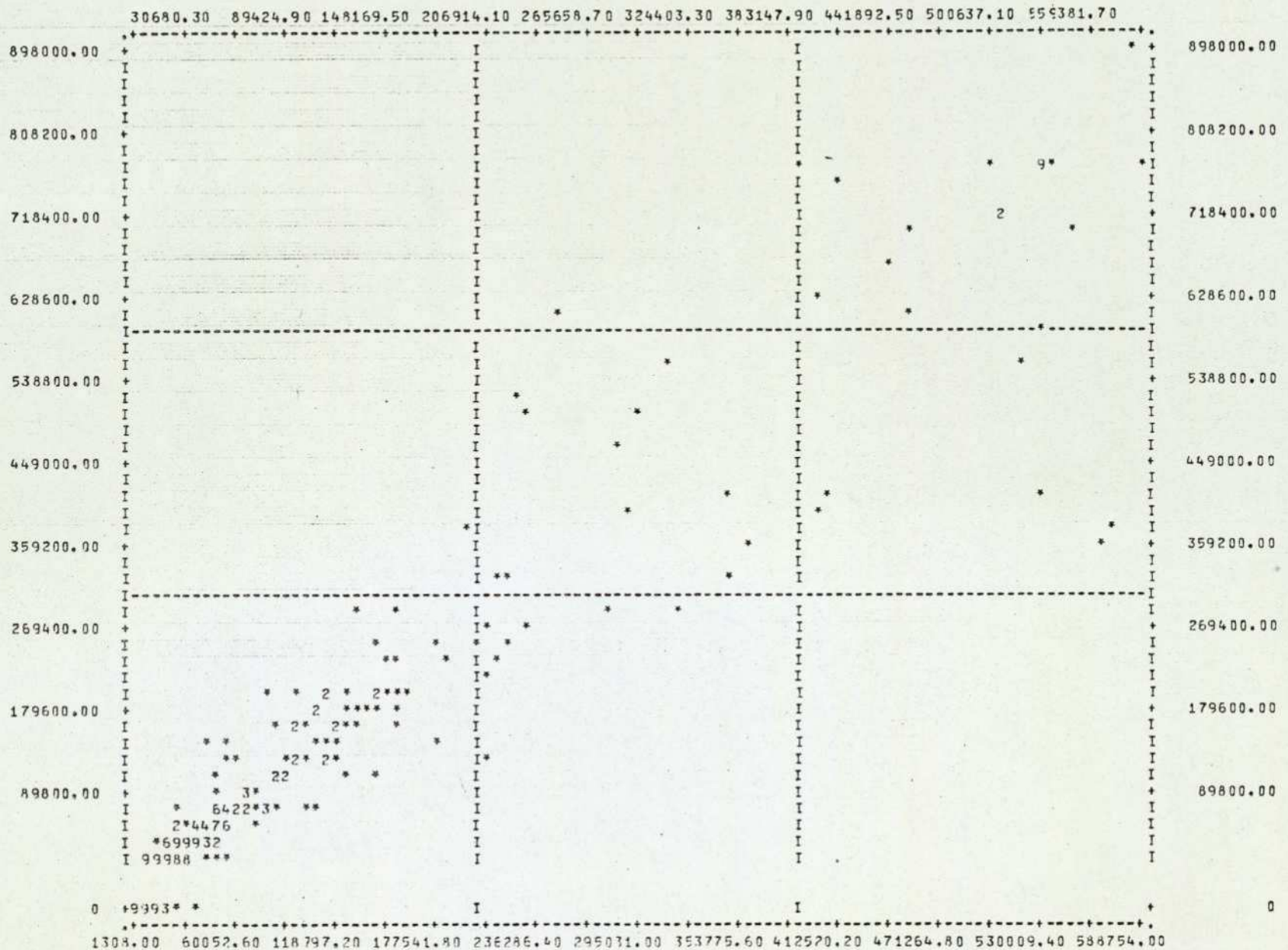
Appendix 5.7 (contd)

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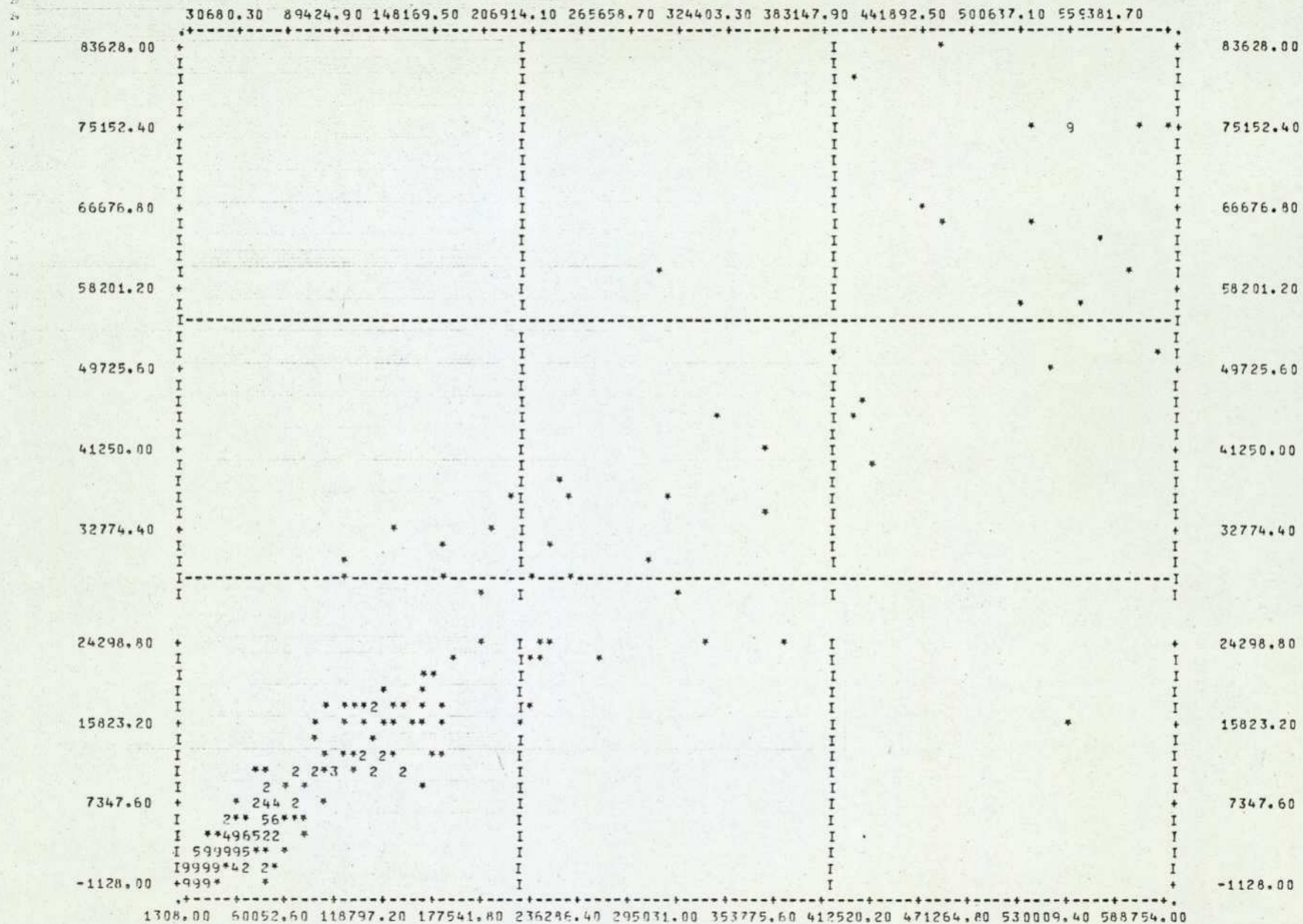
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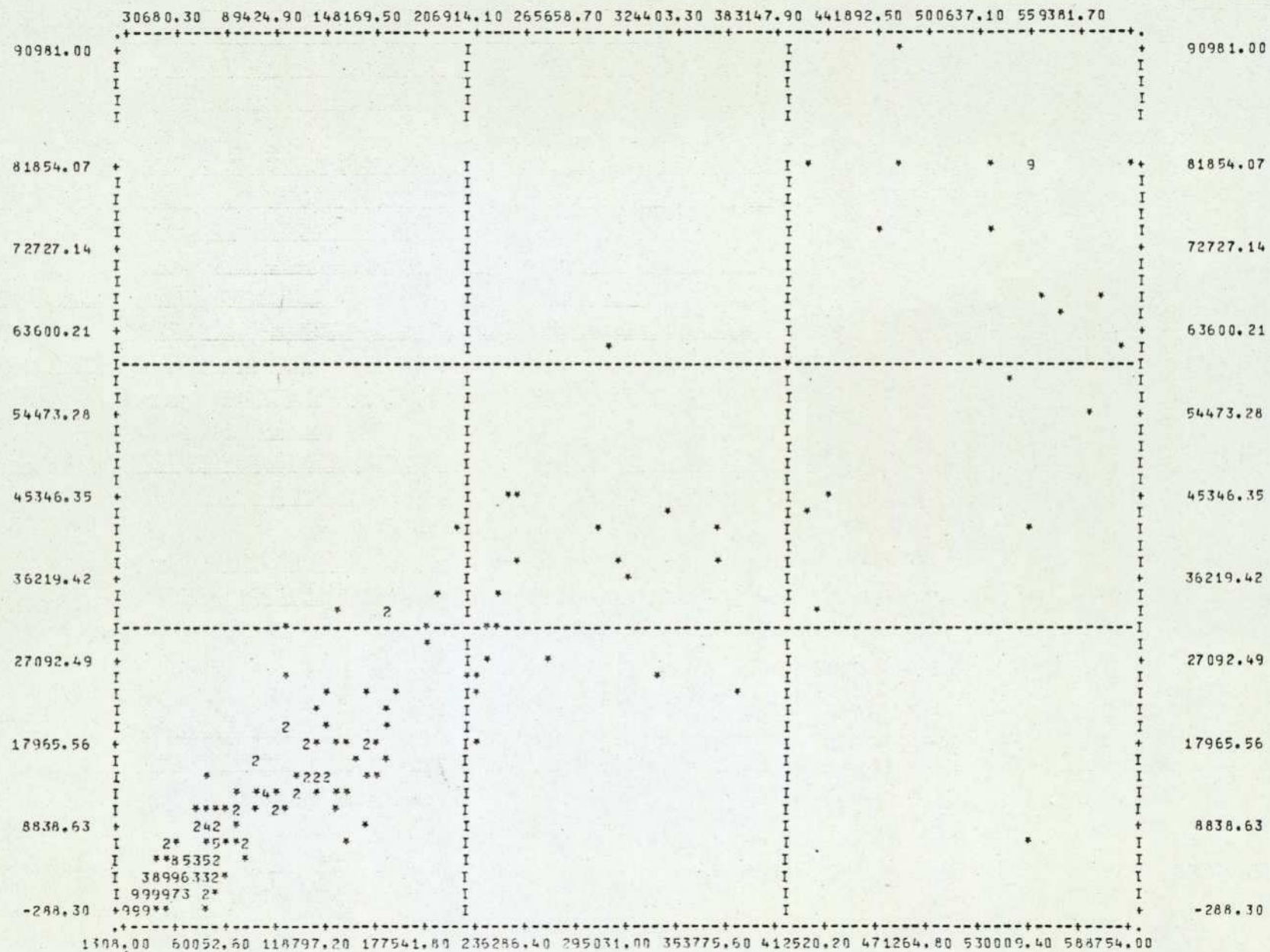
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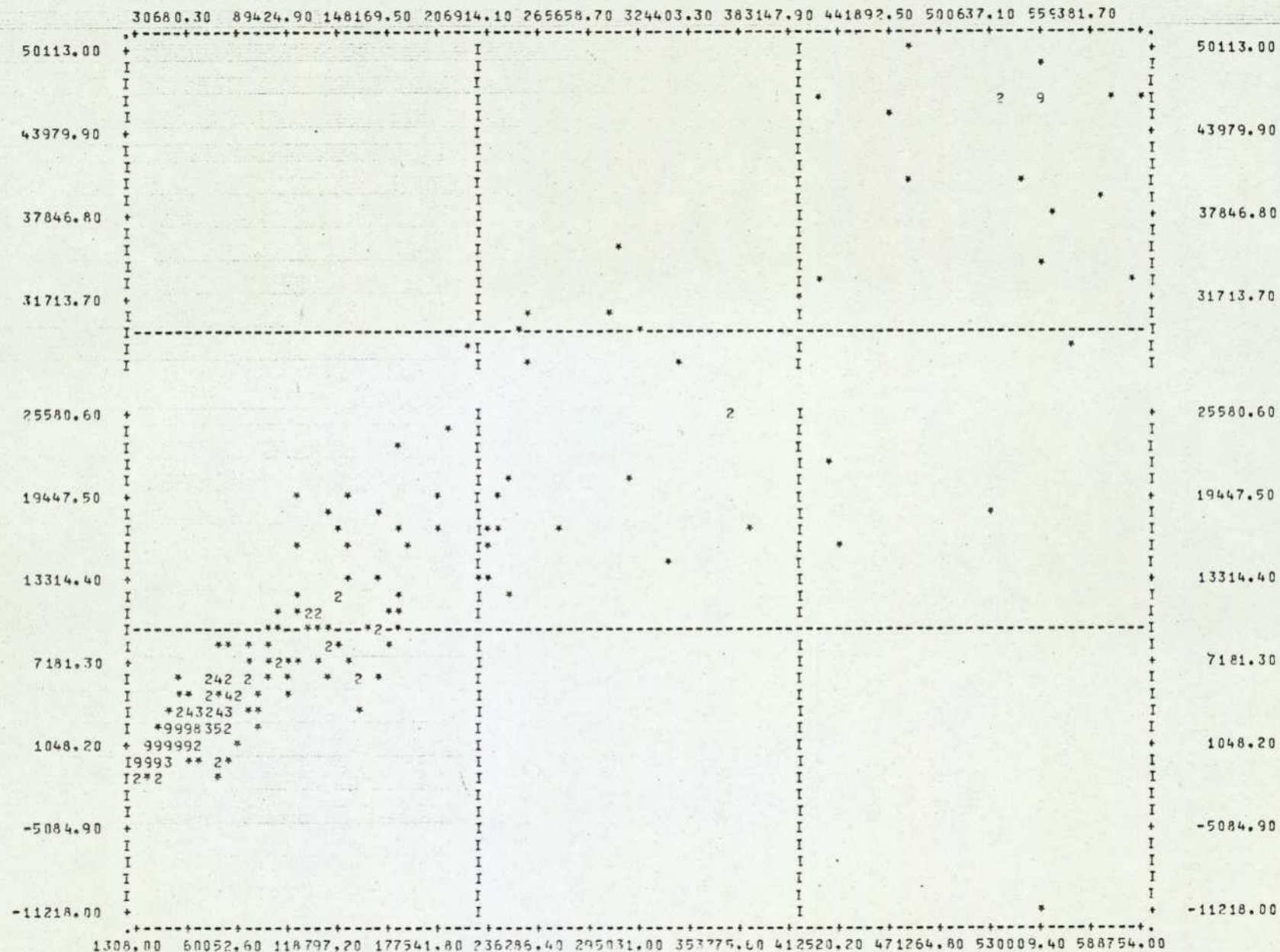
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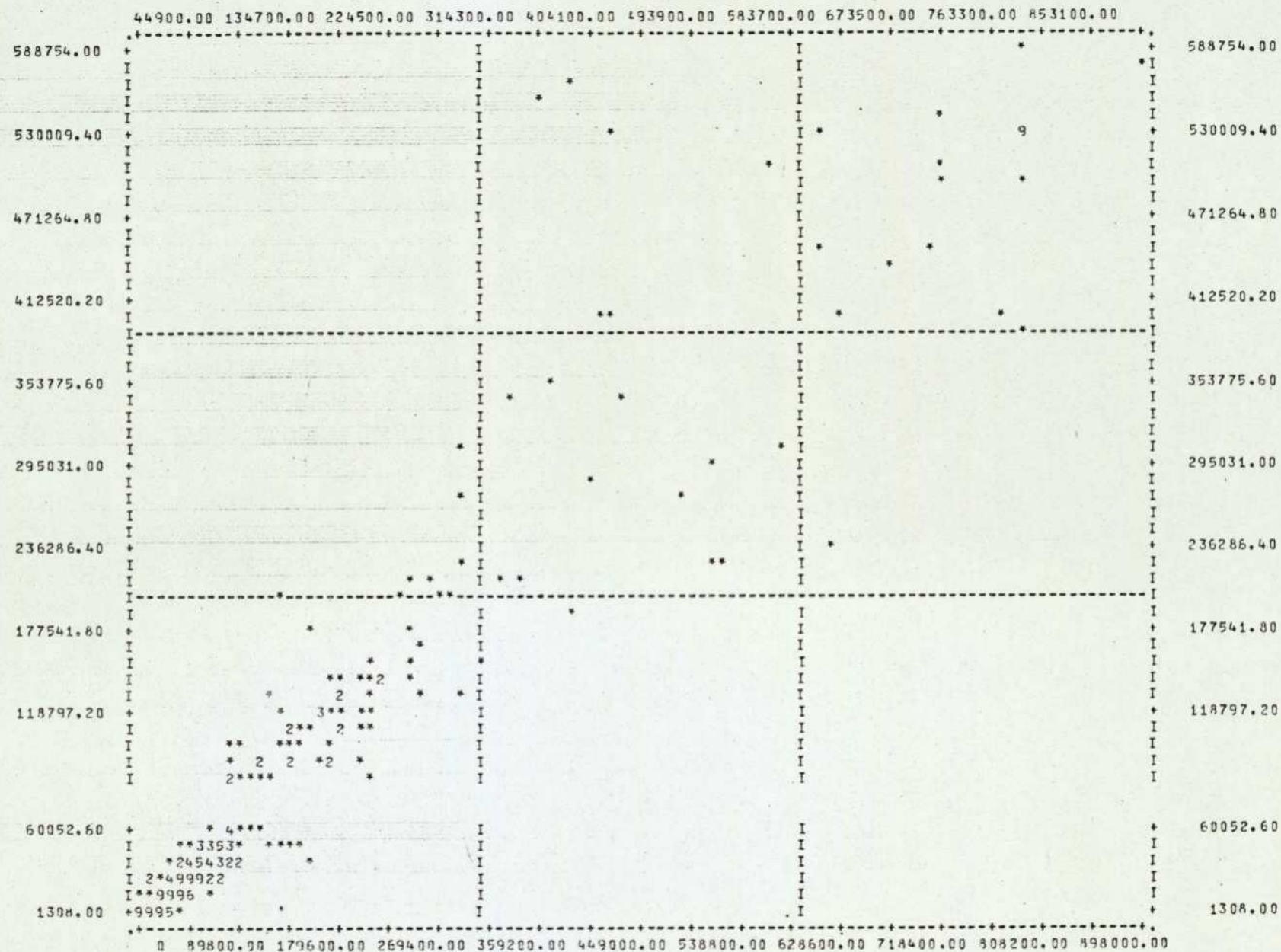
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Appendix 5.7 (contd)

(ACROSS) SALES



Appendix 5.7 (contd)

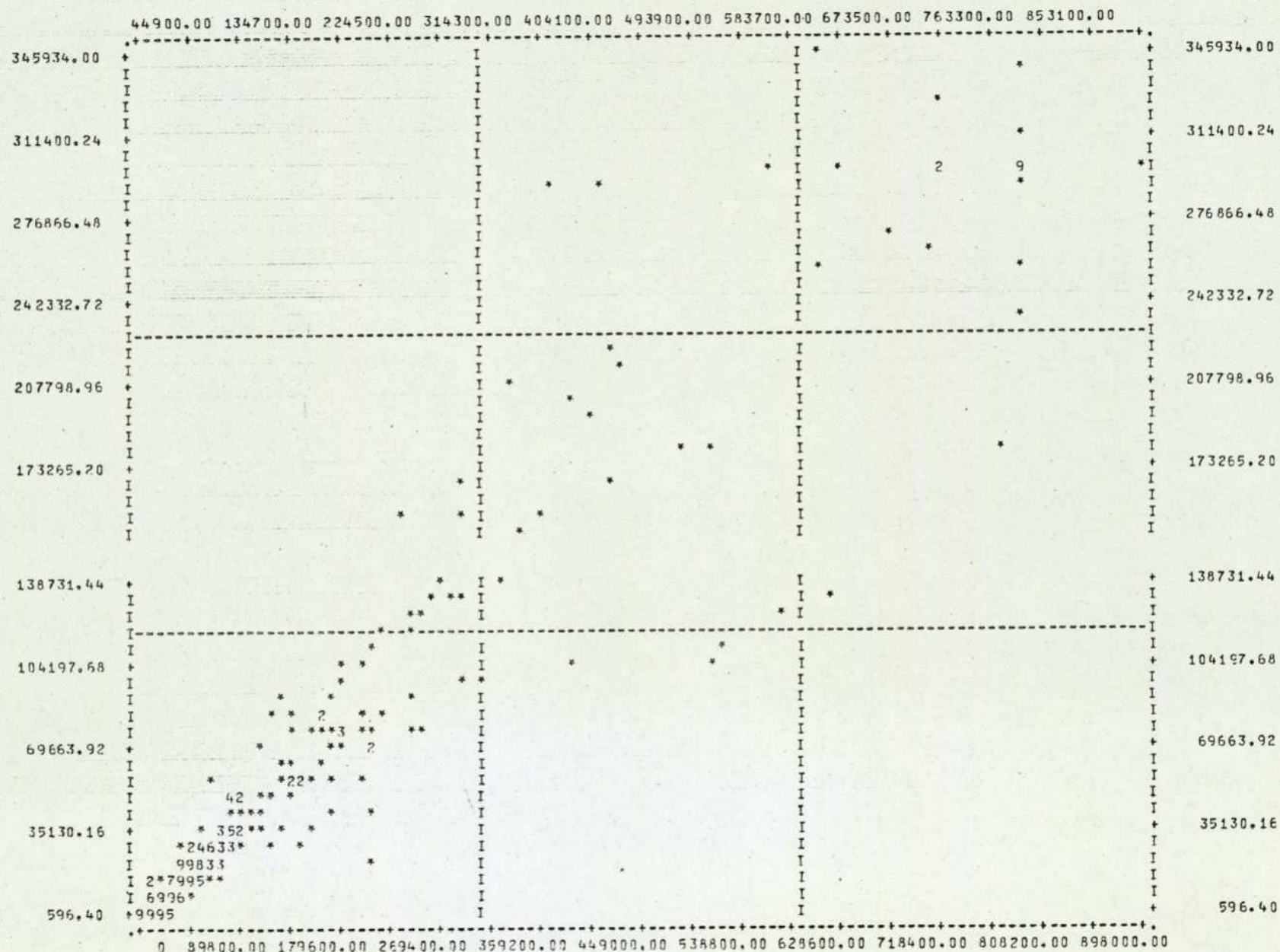
SPURIOUS CORRELATION ANALYSIS

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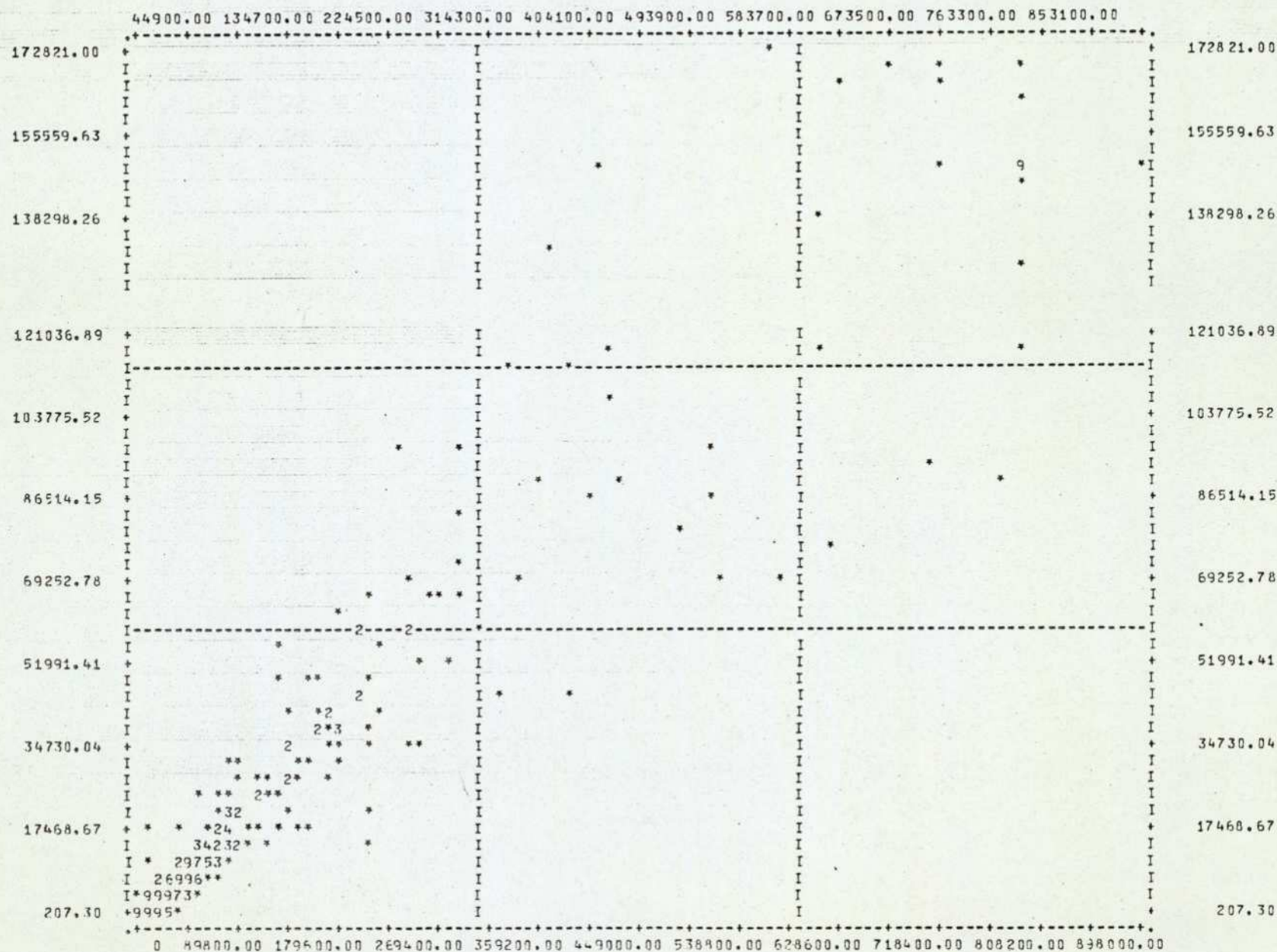
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Appendix 5.7 (contd)

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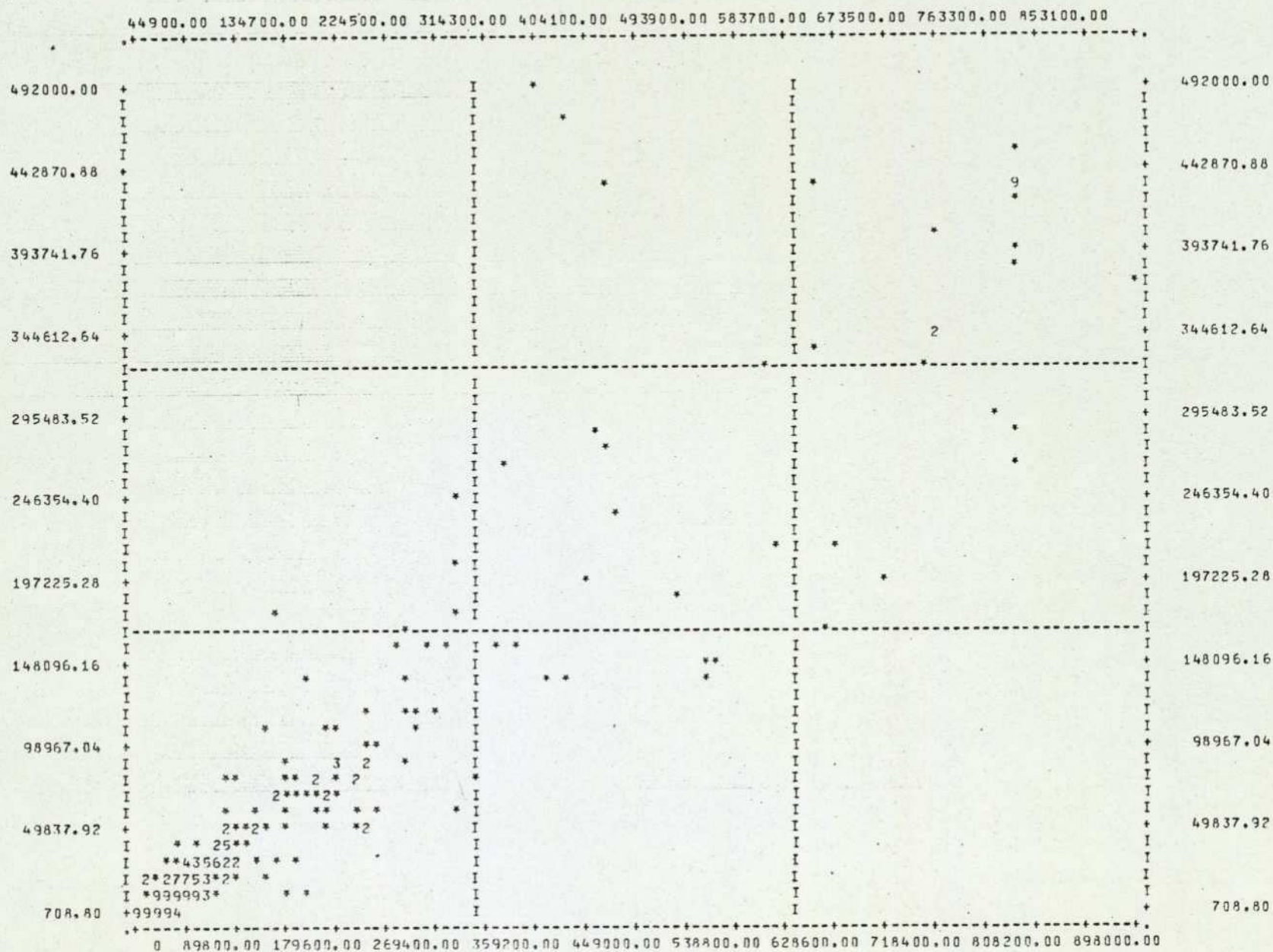
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Appendix 5.7 (contd)

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(ACROSS) SALES



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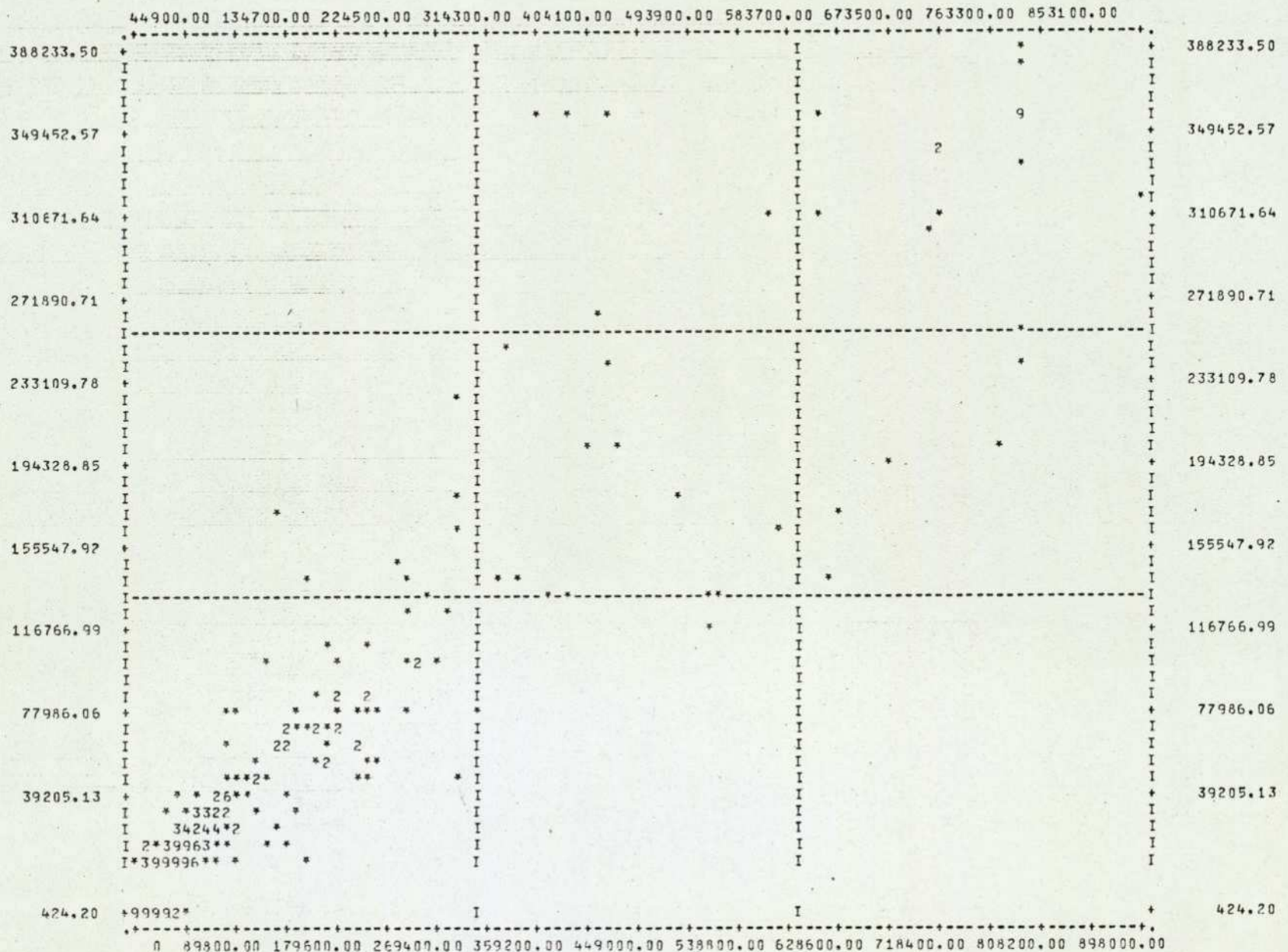
SPURIOUS CORRELATION ANALYSIS

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SCATTERGRAM OF (DOWN) NCE

(ACROSS) SALES



Appendix 5.7 (contd)

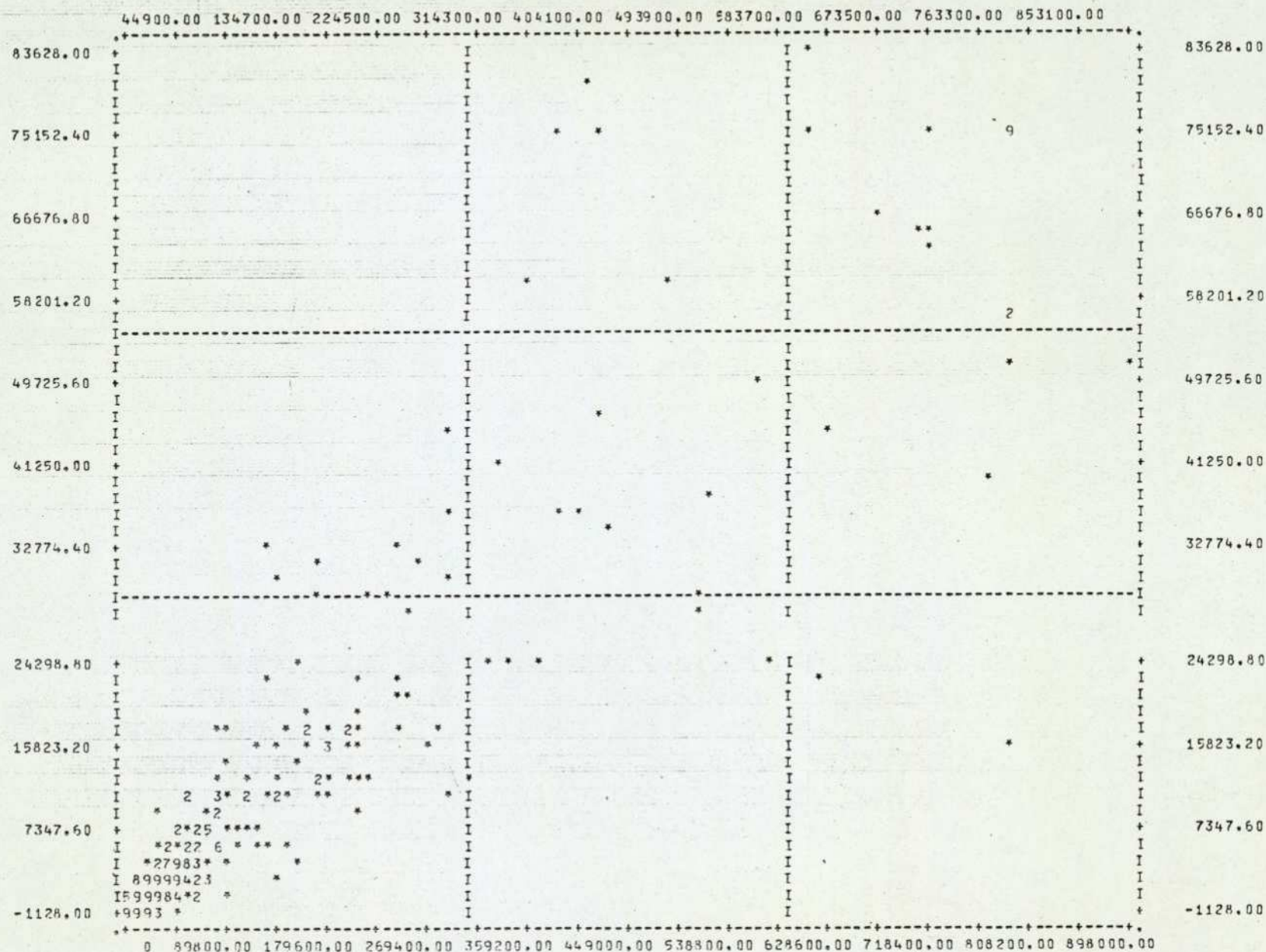
SPURIOUS CORRELATION ANALYSIS

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SCATTERGRAM OF (DOWN) EBIT

(ACROSS) SALES



Appendix 5.7 (contd)

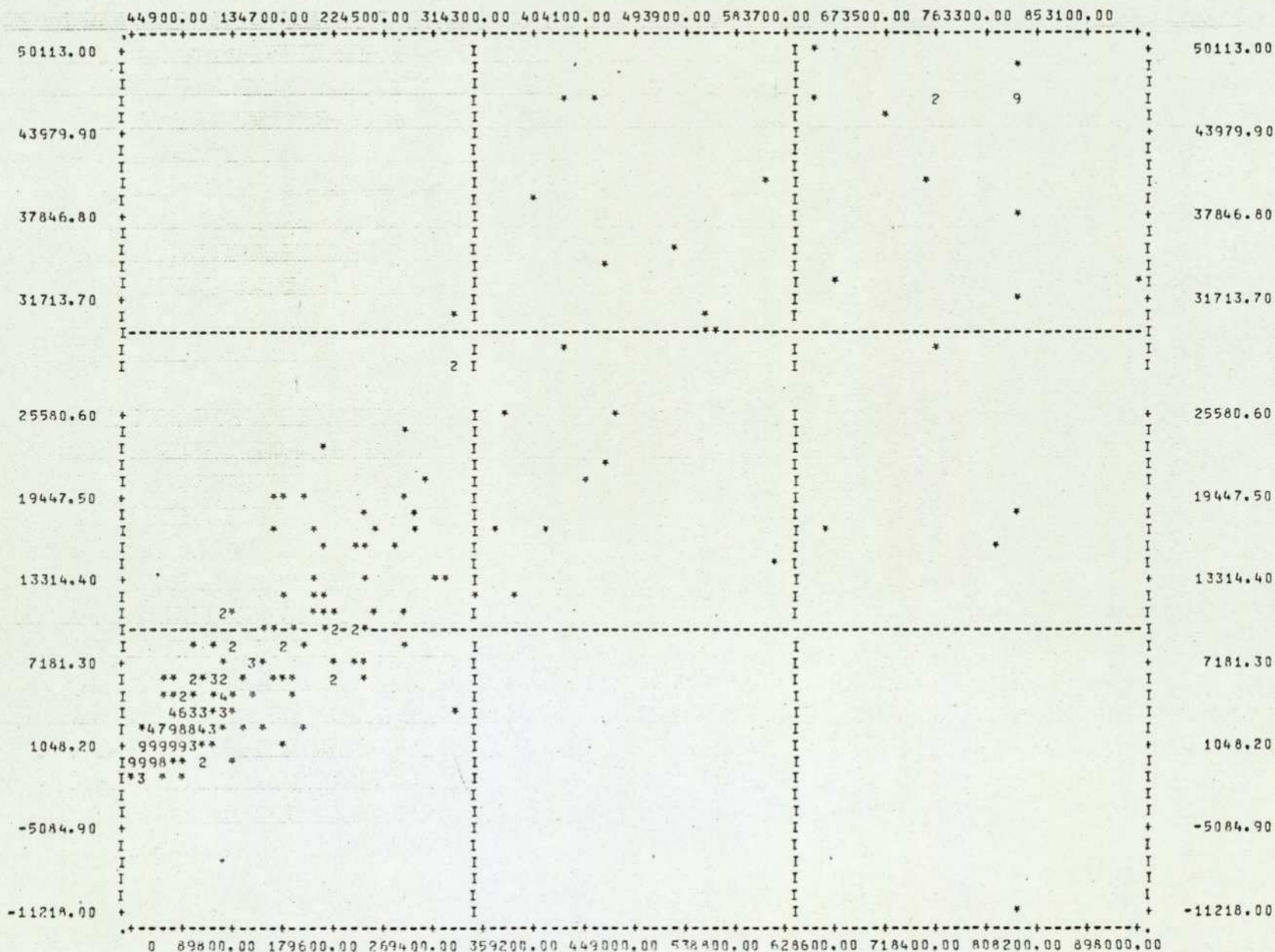
SPURIOUS CORRELATION ANALYSIS

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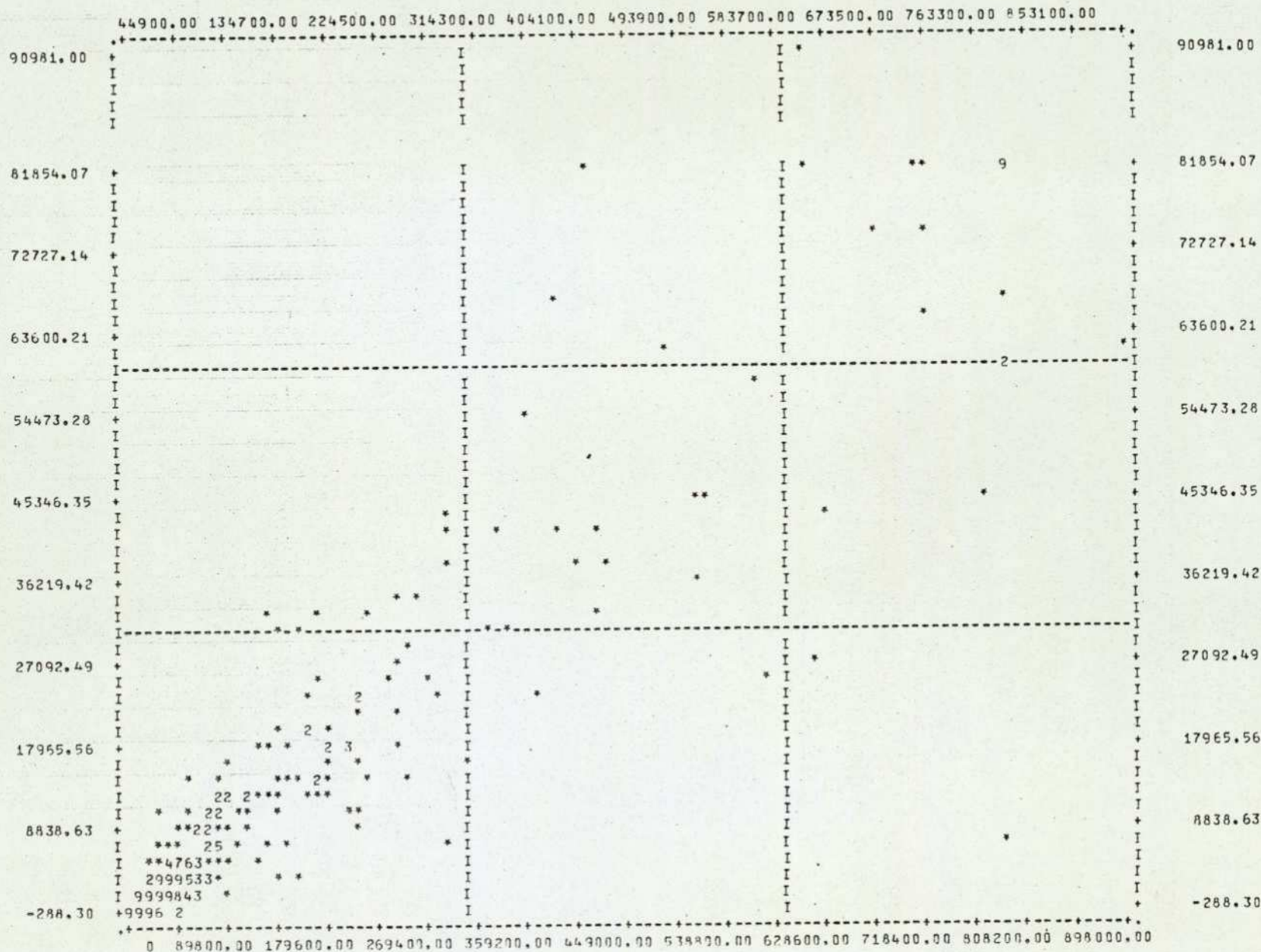
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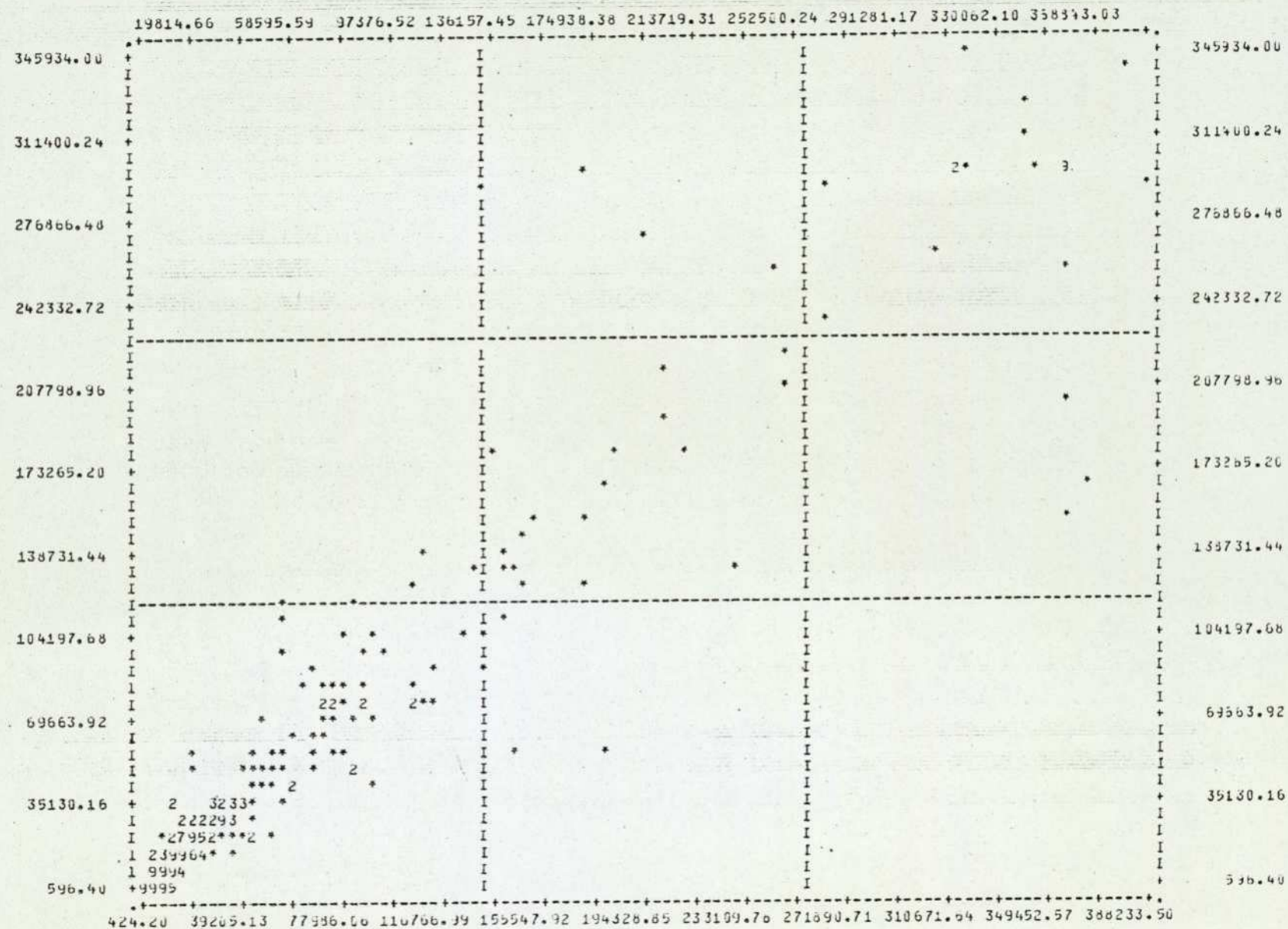
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Appendix 5.7 (contd)

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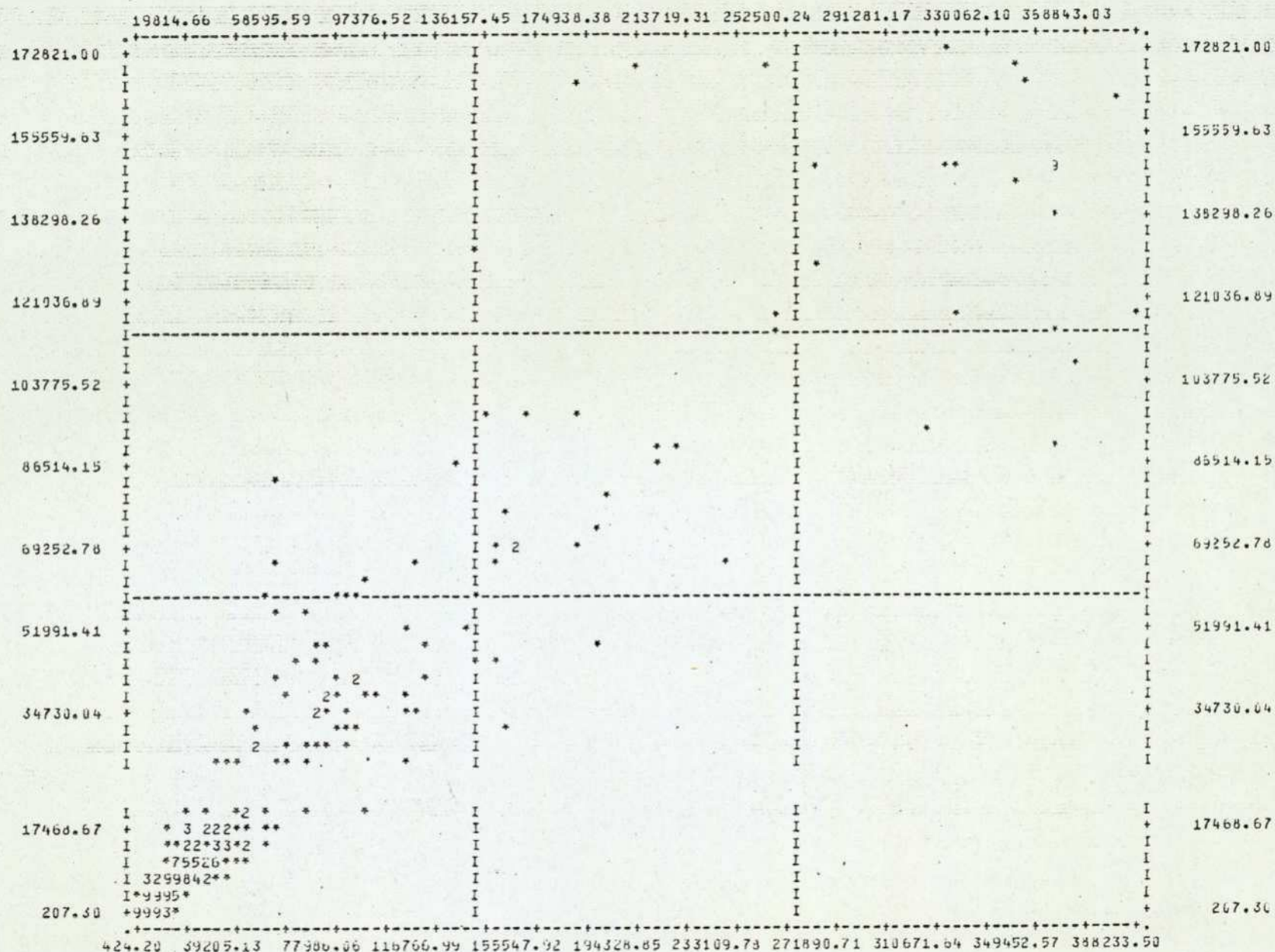
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Appendix 5.7 (contd)

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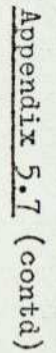
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Appendix 5.7 (contd)

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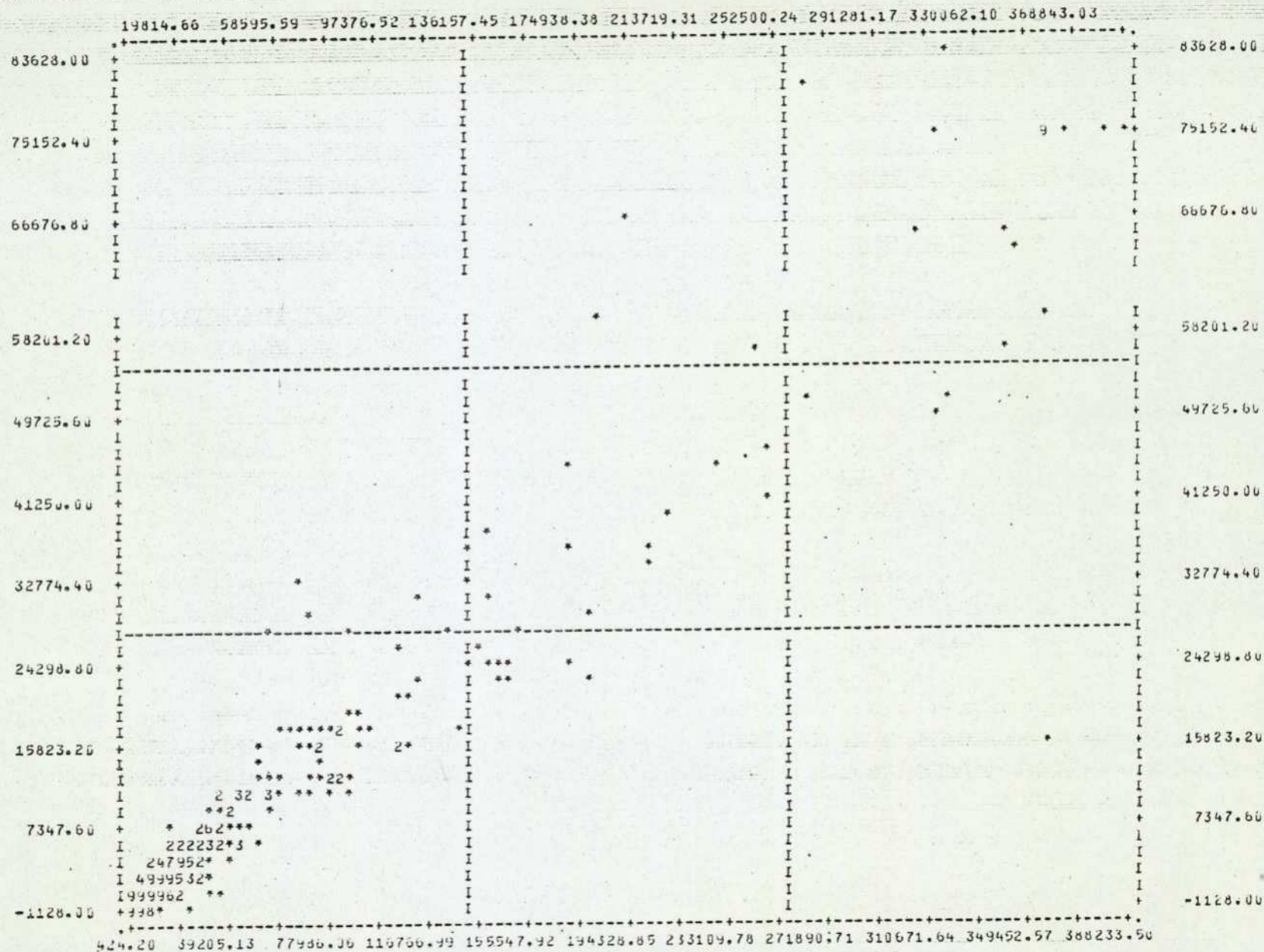


SPURIOUS CORRELATION ANALYSIS

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SCATTERGRAM OF (DOWN) EBIT

(ACROSS) NCE



Appendix 5.7 (contd)

SPURIOUS CORRELATION ANALYSIS

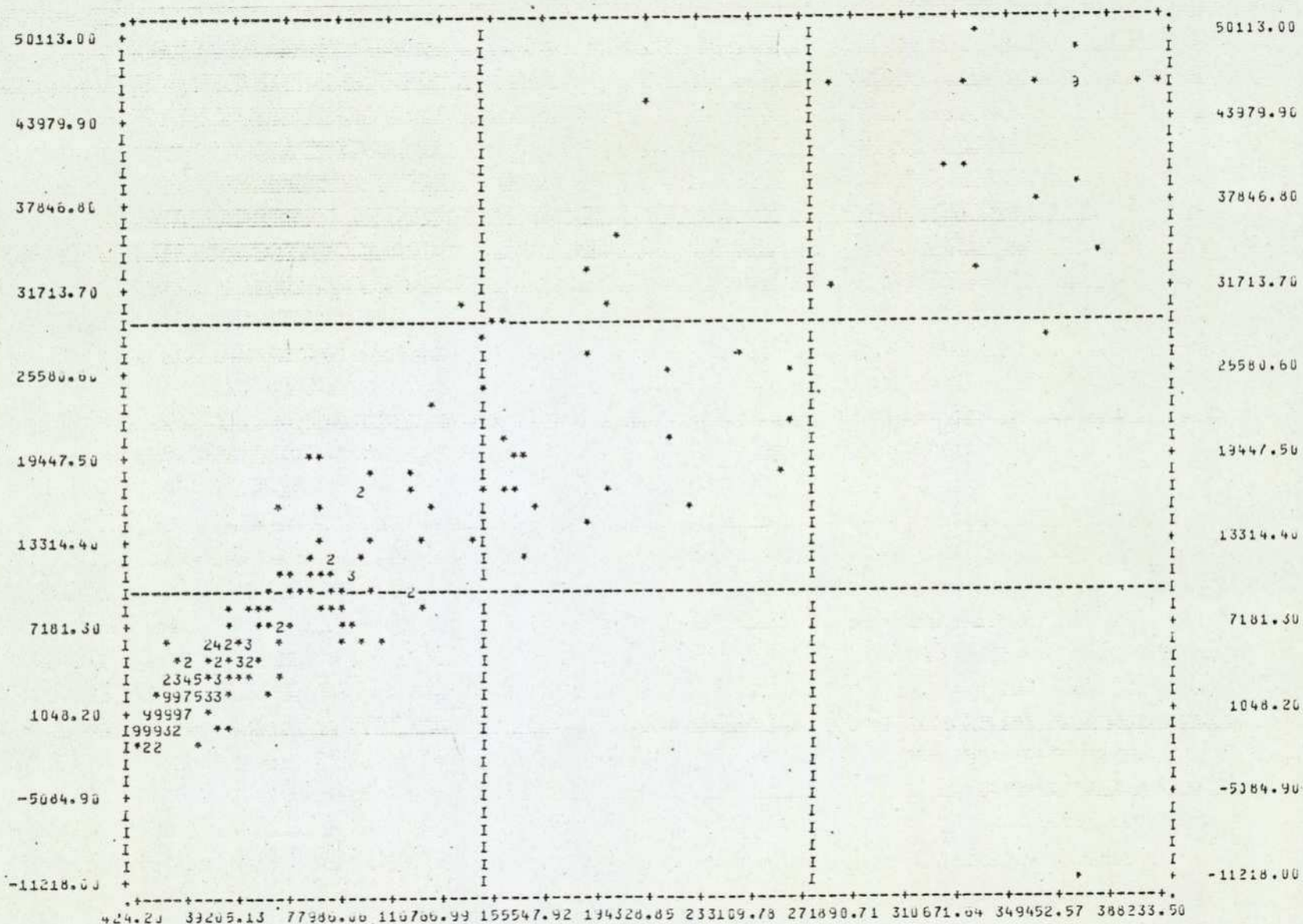
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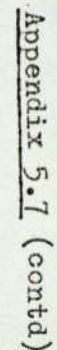


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(ACROSS) NCE



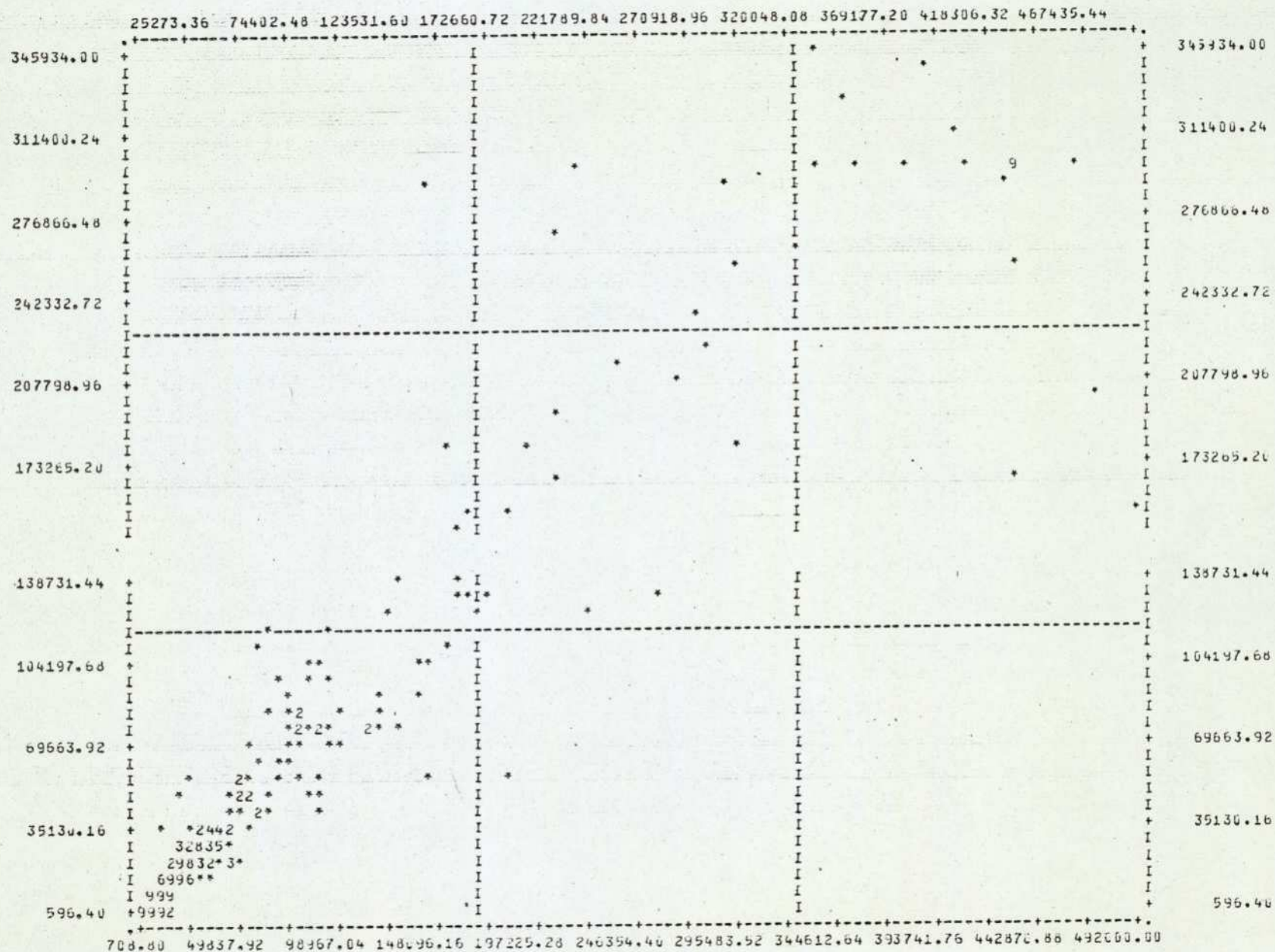
SPURIOUS CORRELATION ANALYSIS

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(ACROSS) TCE



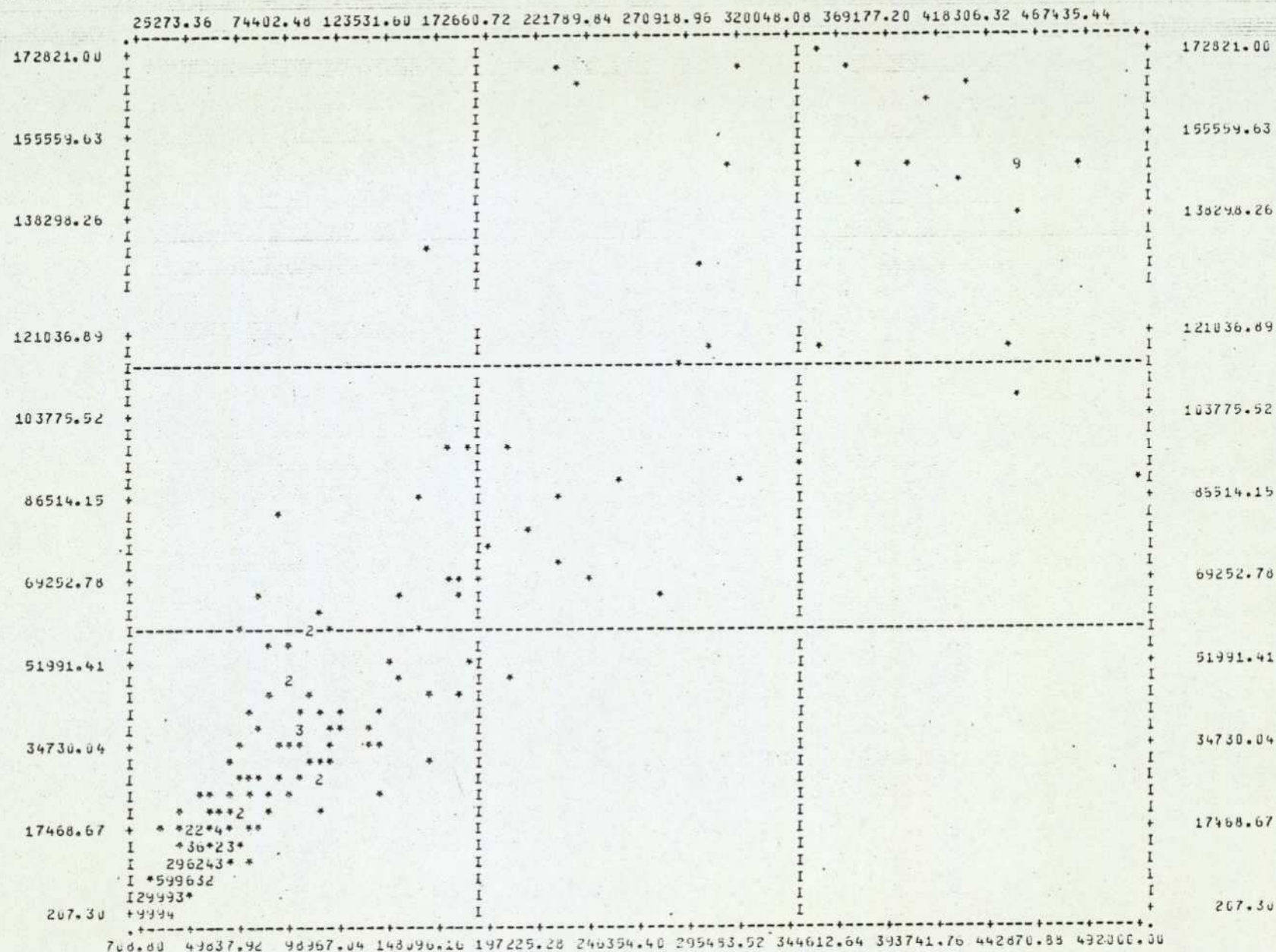
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SPURIOUS CORRELATION ANALYSIS

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SCATTERGRAM OF (DOWN) QA

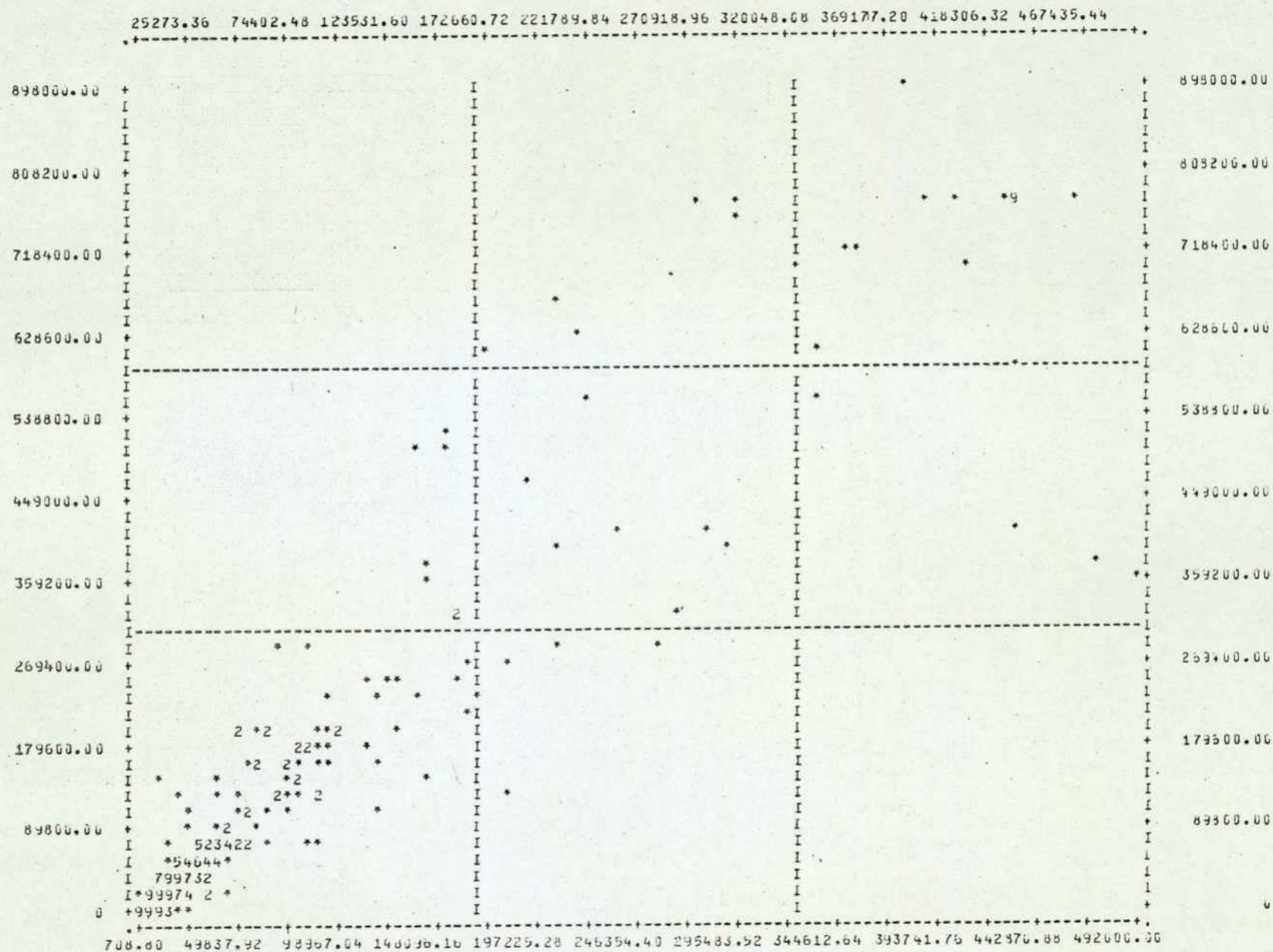
(ACROSS) ICE



Appendix 5.7 (contd)

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(ACROSS) TCE



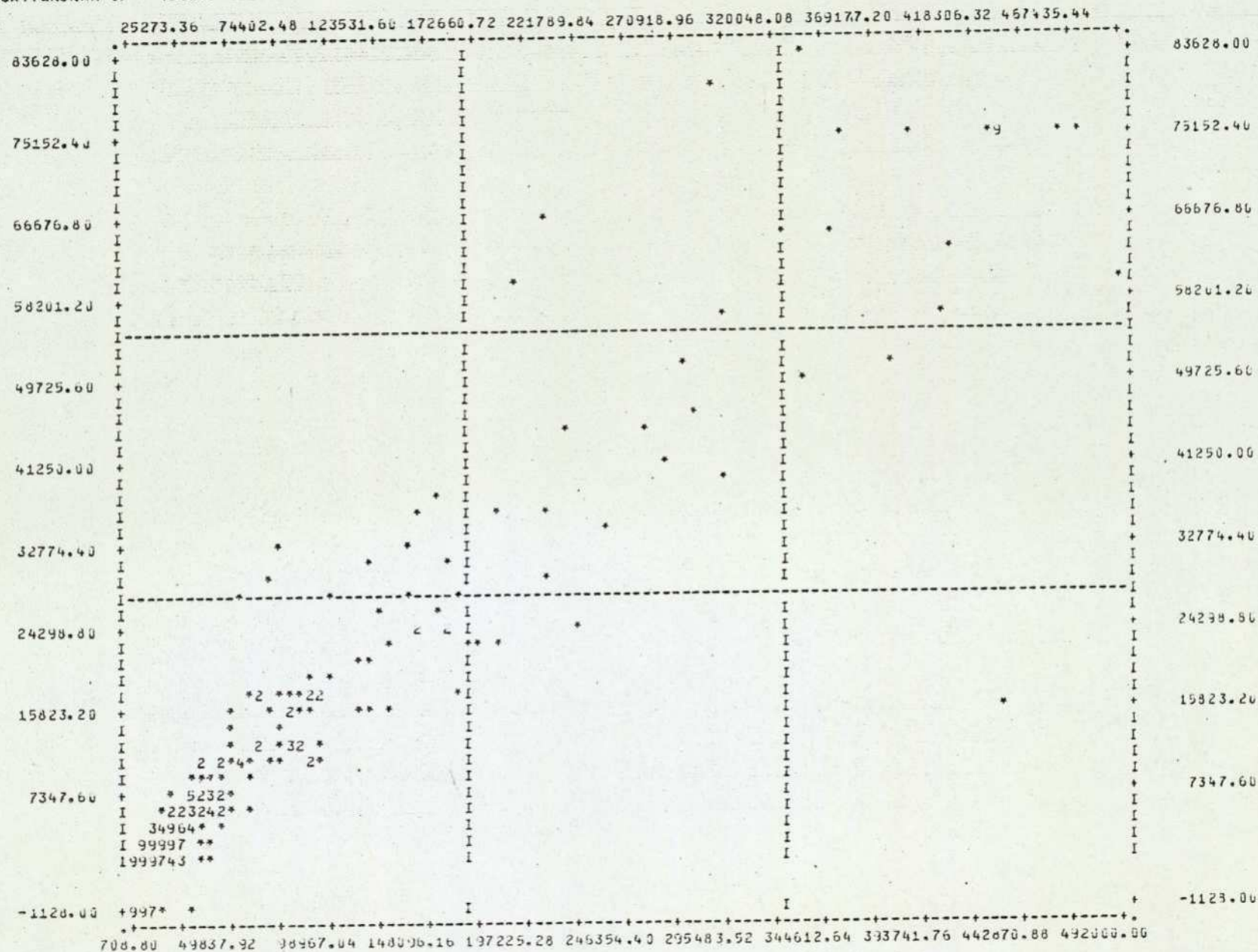
Appendix 5.7 (contd)

SPURIOUS CORRELATION ANALYSIS

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FILE SCATTERG (CREATION DATE = 21/11/79)
SCATTERGRAM OF (DOWN) EBIT

(ACROSS) TCE



Appendix 5.7 (contd)

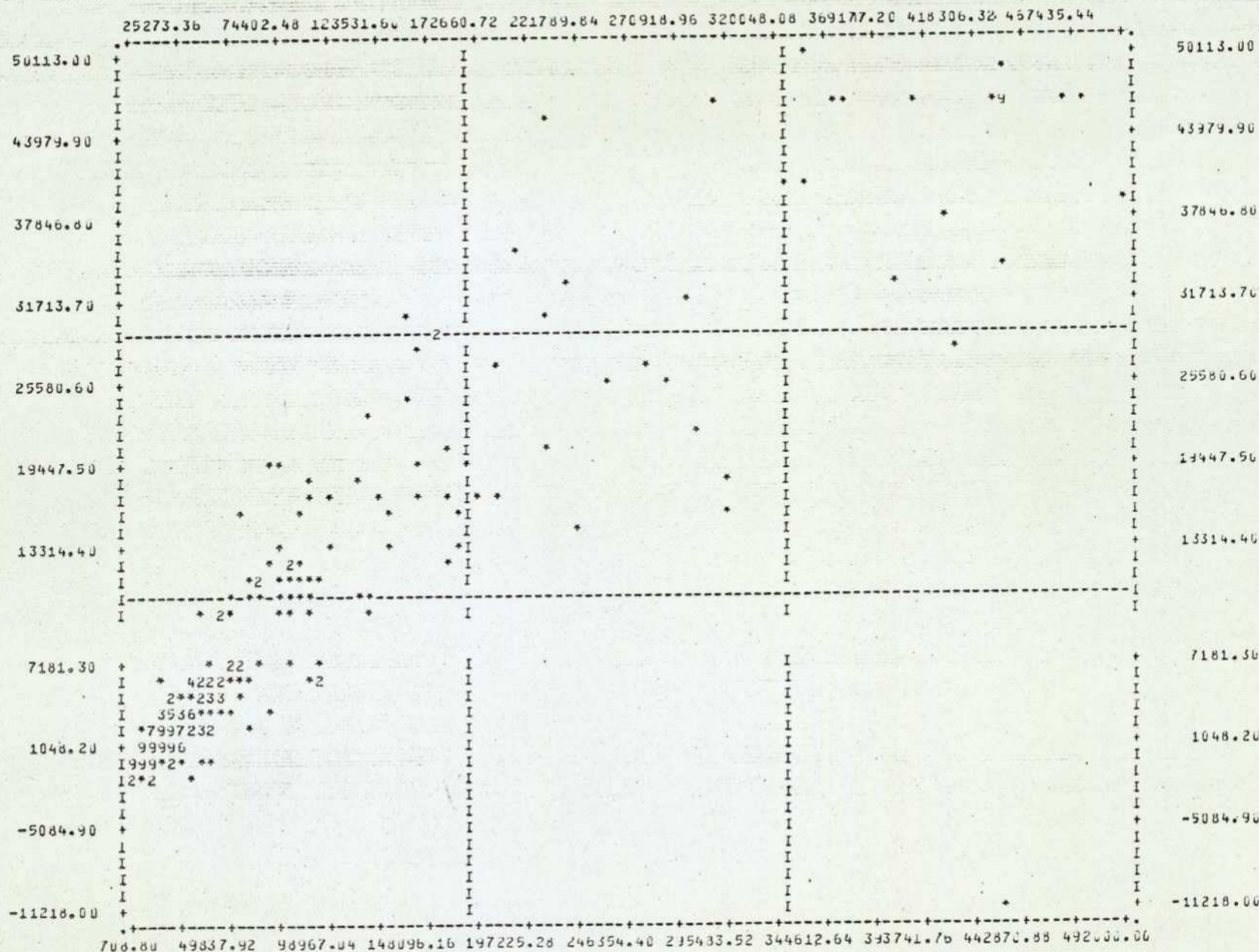
SPURIOUS CORRELATION ANALYSIS

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FILE SCATTERG (CREATION DATE = 21/11/79)
SCATTERGRAM OF (DOWN) CF

(ACROSS) ICE



Appendix 5.7 (contd)

SPURIOUS CORRELATION ANALYSIS

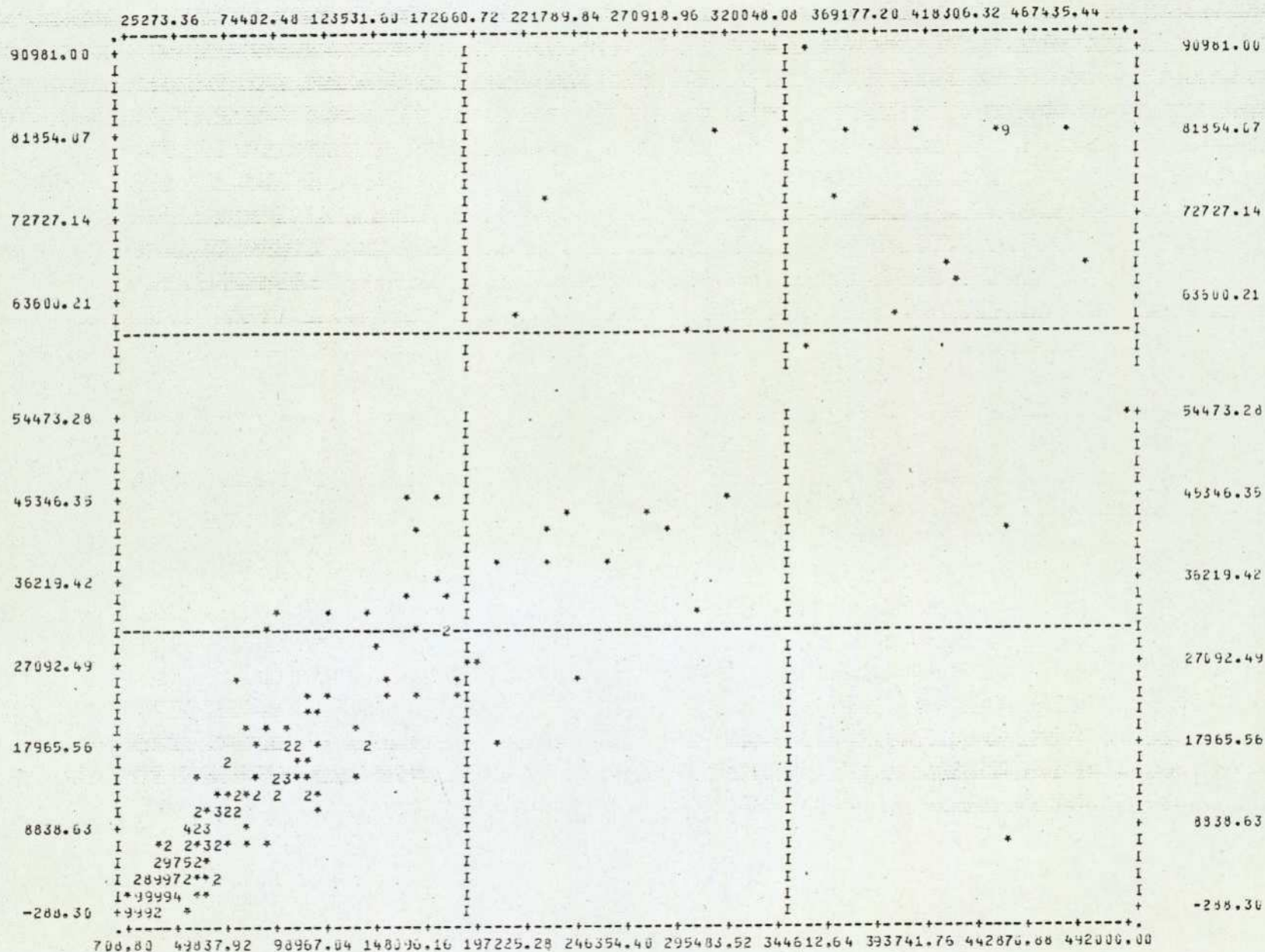
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FILE SCATTERG (CREATION DATE = 21/11/79)
SCATTERGRAM OF (DOWN) FF

(ACROSS) ICE

Output from Scattergram of FF



Appendix 5.7 (contd)

Appendix 5.8

Ratio Distribution Statistics for the Manufacturing
Sample (1977)

RATIO	UNTRANSFORMED					RECIPROCAL					LOG					SQUARE ROOT					SQUARE ROOT OF RECIP				
	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B
TOTALASSETS	1088.89	2.68	9.48	15	4	317.71	1.81	6.21	10	2	91.72	.61	3.19	4	3	555.39	1.91	5.88	13	6	111.43	.85	3.51	4	2
TOTAL NETWORTH	1135.59	2.61	9.18	17	5	269.34	1.55	5.45	5	1	98.28	.72	3.23	3	2	547.38	1.86	5.77	15	5	60.71	.61	3.11	3	1
AV TOTAL CAPEMP	896.60	2.85	10.98	12	2	392.18	1.59	4.79	17	9	87.65	.77	3.13	2	2	551.90	1.91	5.88	15	6	92.07	.84	3.49	3	2
AV NET CAP EMP	1032.14	2.73	9.93	15	4	401.21	1.72	5.30	14	9	75.12	.74	3.08	2	2	585.37	1.90	5.87	14	6	124.39	.90	3.61	2	2
SALES	975.64	2.77	10.29	13	3	389.77	1.58	4.95	20	10	108.69	.77	3.27	1	1	588.63	1.91	5.99	13	5	92.84	.84	3.53	7	5
1 FF / S	23.86	.44	3.77	4	3	268.39	1.46	7.30	4	1	30.50	-.31	3.67	6	4	16.99	.05	3.45	7	5	60.42	.68	4.40	4	2
2 FF / AVICE	20.91	.34	3.72	4	3	83.14	.99	4.80	6	1	24.73	-.28	3.77	4	1	11.43	.03	3.66	4	3	45.50	.65	4.17	4	1
3 FF / AVTA	17.08	-.00	3.56	2	2	201.30	1.62	7.09	6	1	40.21	-.69	3.97	6	3	23.01	-.35	3.57	4	4	100.68	1.10	5.14	6	1
4 VA / S	8.30	.06	3.34	2	1	364.04	1.89	8.80	9	1	60.97	-.93	4.06	9	4	25.46	-.47	3.66	4	2	124.61	1.19	4.90	12	3
5 VA / AVTA	18.92	.43	3.49	4	2	171.48	1.22	5.59	7	1	20.37	-.44	3.60	8	3	9.68	-.07	3.47	4	3	64.16	.76	4.19	7	1
6 VA / AVICE	53.15	.74	3.85	6	3	173.39	1.19	5.21	8	1	25.21	-.34	3.52	5	4	20.24	.21	3.46	5	4	58.25	.73	3.98	7	2
7 VA / AVNCE	51.43	.75	3.82	8	5	162.56	1.14	4.77	11	2	18.03	-.35	3.56	5	4	28.69	.25	3.62	5	4	57.90	.77	3.99	7	3
8 EBIT / S	35.06	.46	4.01	8	3	539.63	2.24	14.30	4	1	21.37	-.17	3.90	6	5	21.97	.14	3.76	9	5	66.53	.63	4.71	6	2
9 EBIT/AVTA	26.76	.82	3.63	4	4	247.92	1.73	7.93	4	1	34.31	-.70	4.24	5	3	21.64	-.33	3.78	4	4	115.52	1.14	5.52	5	1
10 EBIT/AVICE	41.29	.34	3.86	6	4	78.64	.94	5.01	4	1	33.34	-.20	3.97	4	1	25.82	.05	3.83	5	4	44.40	.56	4.27	4	1
11 VA / ER	739.22	2.60	17.00	7	3	33.67	-.46	4.06	8	1	81.87	.87	4.17	13	7	141.87	1.17	5.02	13	6	87.82	-.85	4.97	8	1
12 PBT / S	36.69	.40	4.00	9	3	246.21	1.45	8.58	4	1	21.21	-.13	4.09	8	4	23.06	.08	4.17	6	4	100.11	.73	5.84	5	1
13 PBT / AVTA	23.54	.02	3.63	3	3	137.62	1.36	6.26	5	1	26.47	-.61	4.03	5	3	20.18	-.32	3.77	3	3	69.48	.95	4.92	5	1
14 PBT/AVTNH	28.11	.13	4.32	8	4	42.59	.19	4.73	6	1	37.32	-.01	4.73	5	1	38.60	.10	4.75	5	1	40.60	.12	4.77	5	1
15 PBT/AVTL	74.79	.84	3.98	4	4	941.57	3.55	24.65	4	1	18.68	-.28	3.78	5	4	40.52	.25	3.72	5	5	107.78	.94	5.08	6	2
16 PBT/AVCL	52.50	.56	3.46	2	2	327.36	2.09	9.67	7	2	21.40	-.50	3.71	7	4	25.61	.01	3.44	5	4	106.02	1.10	5.21	8	2
17 PBT/AVICE	38.03	.29	3.84	6	3	49.41	.72	4.53	4	1	22.30	-.14	3.93	3	1	30.23	.08	3.84	4	3	32.87	.44	4.14	3	1
18 PBT/AVNCE	36.45	.16	4.09	5	3	45.25	.27	4.28	4	1	40.67	-.01	4.33	3	1	38.75	.05	4.10	5	2	43.38	.12	4.22	4	1
19 TNI / S	36.31	.13	4.17	8	5	202.97	1.29	8.33	5	1	29.73	-.20	4.23	9	4	24.14	-.05	4.05	10	5	104.87	.67	5.72	8	1
20 TNI/AVTA	23.16	-.28	3.83	5	3	149.10	1.29	5.97	6	1	47.76	-.70	4.34	6	2	28.59	-.49	4.03	5	4	98.08	.98	5.03	5	1
21 TNI/AVNM	52.97	-.13	4.19	6	2	63.25	.35	4.66	5	1	58.28	-.25	4.42	6	1	52.74	-.18	4.35	6	1	59.71	.28	4.59	5	1
22 TNI/AVTL	64.39	.53	4.16	1	1	1381.11	5.33	47.09	3	1	30.58	-.28	3.72	6	3	40.84	.12	3.78	4	3	67.90	.76	4.60	6	2
23 TNI/AVCL	42.52	.29	3.59	2	2	555.37	2.63	14.90	4	1	29.21	-.49	3.72	7	4	28.74	-.14	3.55	4	4	158.99	1.19	6.15	5	1
24 TNI/AVICE	32.17	.06	3.93	3	3	65.55	.73	4.56	5	1	38.59	-.33	4.06	4	1	27.80	-.17	3.95	3	3	42.04	.54	4.32	4	1
25 TNI/AVNCE	33.44	-.09	4.09	5	3	56.92	.46	4.60	4	1	40.35	-.24	4.35	4	1	39.04	-.14	4.29	4	1	50.54	.35	4.46	4	1

Appendix 5.8 (contd)

RATIO	UNTRANSFORMED					RECIPROCAL					LOG					SQUARE ROOT					SQUARE ROOT OF RECIP				
	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B
26 CF / S	35.00	.31	3.82	8	5	91.27	.54	5.26	5	1	18.16	-.06	3.88	8	3	23.20	.15	3.78	7	6	53.19	.27	4.55	6	1
27 CF/AVTA	11.22	-.09	3.57	7	5	89.64	.95	4.85	5	1	35.23	-.43	4.04	5	1	21.42	-.25	3.81	6	3	58.34	.69	4.32	5	1
29 CF / AVTL	69.40	.65	3.96	3	2	217.45	1.28	6.67	5	1	24.50	-.14	3.48	5	3	35.17	.22	3.67	3	3	61.97	.60	4.32	5	1
30 CF / AVCL	50.62	.49	3.74	1	1	245.64	1.69	8.69	4	1	18.14	-.31	3.48	5	3	23.35	.08	3.42	4	3	92.08	.80	4.65	5	1
31 CF / AVTCE	22.82	.24	3.97	4	3	33.27	.47	3.98	5	1	25.12	-.13	3.93	3	1	23.52	.06	3.91	3	3	29.64	.31	3.94	4	1
32 CF / AVNCE	38.69	.16	4.09	5	3	43.91	.17	4.33	3	1	41.18	.05	4.28	3	1	40.19	.13	4.22	4	1	39.06	.06	4.28	3	1
33 OSCF/AVOSE	42.66	.27	4.18	5	2	40.75	-.08	4.36	3	1	44.90	.16	4.20	5	1	43.84	.23	4.22	5	1	45.58	-.12	4.28	4	1
34 DR / CA	16.49	-.22	3.57	2	2	196.29	1.61	5.78	12	5	78.53	-.96	4.28	8	5	39.39	-.64	3.86	5	5	125.33	1.27	4.79	11	6
35 DR / XINV	87.05	.93	4.36	12	6	170.57	1.26	5.24	14	5	40.54	-.31	4.15	7	3	51.67	.38	3.99	8	5	82.59	.75	4.20	12	6
36 CA / CL	82.45	.88	3.80	6	5	36.37	.57	3.41	6	3	23.23	.13	3.60	3	2	41.93	.52	3.57	5	4	21.57	.26	3.41	3	3
37 FA / TA	43.42	.70	3.66	0	0	122.70	1.13	4.02	9	5	11.96	-.39	3.23	3	3	9.42	.14	3.19	0	0	60.82	.80	3.56	5	4
38 WC / TNW	33.42	-.53	3.55	6	1	11393.54	4.2530.05	4	1	77.50	-.99	4.18	10	5	51.11	-.79	3.65	9	6	424.30	1.8310.69	5	1		
39 WC / TL	101.33	1.03	4.06	6	5	277.86	1.63	7.69	6	1	19.36	-.13	3.70	4	2	41.29	.49	3.73	5	4	62.07	.72	4.22	6	1
40 TA / ER	523.08	2.8713.49	10	4	41.51	.62	3.56	5	2	51.90	.62	3.89	12	8	155.99	1.26	5.65	10	5	17.15	-.10	3.81	7	2	
41 WC / XNCE	30.37	-.58	3.36	5	1	50.18	.77	3.73	5	1	40.49	-.67	3.52	5	1	36.50	-.62	3.44	5	1	45.95	.72	3.62	5	1
42 WC / DR	82.82	.86	4.76	11	4	77.23	.50	5.16	5	1	41.71	.22	4.70	8	2	45.88	.55	4.52	10	5	45.25	.19	4.75	8	1
43 AVWC / S	17.96	.33	3.21	4	2	29.71	.66	3.77	3	1	18.52	-.14	3.24	3	1	10.60	.13	3.34	2	2	18.37	.39	3.43	3	1
44 TL / TNW	95.68	1.04	3.96	11	7	140.59	1.11	4.05	10	5	7.10	-.02	3.37	1	0	42.56	.61	3.50	7	4	45.69	.64	3.41	5	4
45 TL / TA	9.97	.16	2.93	1	1	141.44	1.17	4.04	9	5	32.80	-.59	3.34	3	2	11.30	-.22	3.03	1	1	76.05	.93	3.72	4	4
46 DEBT / QA	156.29	.87	3.22	6	4	2872.52	2.87	9.28	0	0	552.88	1.90	5.77	0	0	143.16	-.10	2.75	1	1	11335.92	2.77	8.86	0	0
47 EBIT/AVTL	87.69	.85	4.00	4	4	424.41	2.0510.62	4	1	25.61	-.27	3.83	4	4	43.80	.30	3.66	6	5	122.86	.96	5.40	4	1	
48 TA / TNW	95.68	1.04	3.96	11	7	9.93	-.16	2.93	1	0	45.89	.65	3.47	6	4	71.65	.84	3.61	10	6	21.36	-.47	3.18	3	2
49 QA / TNW	77.85	.91	3.94	8	6	95.31	.97	3.92	10	5	2.59	-.15	3.52	2	1	24.58	.41	3.61	4	2	32.99	.61	3.59	6	4
50 CA / TNW	71.04	.82	3.82	11	7	102.08	.89	4.14	8	4	25.71	-.02	3.84	3	2	36.41	.47	3.87	6	4	46.24	.49	3.83	4	3
51 CL / TNW	121.12	1.13	4.11	12	7	92.73	1.03	3.99	8	6	8.82	.11	3.33	1	0	43.01	.72	3.63	7	4	25.90	.53	3.36	5	4
52 AVTNW / S	47.50	.77	3.46	7	7	149.43	1.28	4.51	13	7	28.20	-.24	3.91	3	2	11.50	.28	3.34	7	5	83.48	.85	4.11	8	5
53 DEBT / TNW	136.74	.96	3.76	9	5	52755.59	2.73	9.03	1	0	455.86	1.73	5.13	1	0	136.02	-.00	2.89	3	3	21390.74	2.56	8.34	1	0
54 DEBT/TCE	97.97	.36	2.63	2	2	12768.48	2.85	9.19	0	0	639.14	1.92	5.66	0	0	235.79	-.55	2.78	0	0	01442.91	2.69	8.52	0	0
55 CA / TL	126.92	1.02	3.96	6	5	37.87	.58	3.40	4	4	21.03	.20	3.42	4	3	36.21	.63	3.65	4	3	12.81	.19	3.19	4	4

Appendix 5.8 (contd)

RATIO	UNTRANSFORMED					RECIPROCAL					LOG					SQUARE ROOT					SQUARE ROOT OF RECIP				
	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B
56 AVCR/COS	24.18	.46	3.30	4	3	154.53	1.23	4.34	9	6	35.83	-.42	3.53	6	5	16.72	.00	3.35	3	3	74.46	.85	1.94	7	5
57 COSZ/AVINV	245.03	1.56	5.66	8	2	24.27	.61	3.60	4	4	40.49	.60	3.58	5	2	113.66	1.97	4.21	8	2	14.66	-.02	3.48	2	2
58 AVQA/PDOE	127.77	.99	5.26	5	1	155.48	1.33	4.99	15	6	49.59	-.33	4.33	5	3	41.77	.24	4.07	5	2	96.81	.90	4.66	9	7
59 AVQA / S	46.24	.54	4.03	7	3	167.66	1.34	4.92	16	7	66.29	-.50	4.22	8	5	42.54	.00	4.20	4	2	103.47	.99	4.76	12	6
60 AVCA / S	29.92	.47	3.82	2	2	119.54	1.21	4.88	8	3	32.17	-.45	3.79	4	4	15.17	.06	3.56	3	3	64.36	.85	4.35	6	3
61 S / AVFA	88.65	1.08	4.02	11	7	134.18	1.24	4.29	14	9	13.47	-.04	3.91	3	3	26.04	.61	3.50	10	7	45.19	.78	3.97	8	5
62 S / AVTA	73.38	.93	4.39	10	6	31.84	.69	3.94	9	6	34.58	.09	4.29	3	3	41.03	.56	4.18	8	5	23.99	.32	4.03	8	2
63 S / AVCE	98.30	1.03	4.09	11	6	53.60	.83	3.94	11	6	16.46	.15	3.99	5	5	45.54	.60	3.93	8	6	22.62	.40	4.00	7	3
64 S / AVNDE	134.68	1.24	4.51	14	8	38.25	.80	3.69	11	7	31.41	.22	3.92	4	4	70.34	.78	4.19	8	4	19.68	.36	3.71	7	4
65 S / AVINV	257.72	1.57	5.75	8	2	29.94	.57	3.55	4	3	46.11	.59	3.57	6	2	103.84	1.09	4.34	7	2	14.18	-.05	3.46	2	2
66 DAYS DEBIQS	36.97	-.33	3.54	3	2	339.31	1.75	5.64	18	10	140.94	-1.15	4.41	14	9	78.08	-.86	4.49	4	2	236.84	1.43	4.83	17	10
67 QA / CL	89.07	.93	3.88	6	5	53.19	.93	4.18	9	4	20.84	.06	3.72	3	2	35.02	.48	3.63	5	4	33.63	.53	3.83	4	3
68 QA / TL	116.36	1.16	4.34	7	4	37.82	.75	3.71	8	6	20.33	.16	3.56	4	3	70.01	.72	3.87	3	3	15.69	.34	3.64	6	3
69 MC / XINV	55.44	.23	4.43	10	4	526.78	.62	3.41	4	1	49.14	-.14	4.41	10	3	46.70	.06	4.34	11	4	176.59	.23	6.76	7	1
70 XINV / CA	17.41	-.25	3.67	3	2	328.09	2.04	8.78	7	2	69.98	-.97	4.51	7	3	39.39	-.59	3.74	7	5	166.63	1.44	6.08	7	2
71 QA-CL/PDOE	38.74	.13	4.09	5	1	94.54	.82	5.21	5	1	40.12	-.30	4.25	5	2	29.86	-.06	4.07	5	2	75.85	.61	4.91	4	1
72 EDIV/OSEI	80.58	.83	4.09	10	6	296.29	1.93	6.15	22	17	92.09	-.82	4.03	20	17	51.20	-.22	4.77	2	2	163.93	1.39	4.70	20	17
73 EDIV/OSNI	113.05	.55	4.77	24	6	262.11	.92	4.99	37	17	130.52	-.83	3.95	30	17	114.22	-.33	4.51	18	4	148.41	.61	4.16	33	17
74 CL / TA	14.07	.47	3.19	1	1	82.88	.99	3.81	8	6	10.70	-.33	3.35	0	0	13.35	.08	2.99	1	1	42.65	.71	3.54	5	4
75 QA / TA	16.58	.42	3.45	2	2	104.49	1.08	4.10	6	3	24.79	-.42	3.36	1	1	11.15	.01	3.23	1	1	59.03	.77	3.64	4	2
76 CA / TA	42.82	-.70	3.66	0	0	167.34	1.41	4.58	11	9	91.20	-1.05	3.89	9	6	64.37	-.90	3.75	5	4	134.74	1.23	4.20	10	7
77 DEBT / TA	87.44	.42	2.58	1	1	11770.33	2.82	9.08	0	0	566.69	-1.81	5.30	0	0	207.97	-.52	2.55	0	0	1469.02	2.62	8.22	0	0
78 DEBT / CA	159.99	.73	3.24	3	3	2768.42	2.85	9.18	0	0	940.47	-1.83	5.47	0	0	174.54	-.25	2.77	2	2	21395.66	2.68	8.50	0	0
79 TNI / AVTNW	52.54	-.11	4.25	6	2	66.08	.37	4.74	5	1	57.42	-.24	4.49	6	1	51.06	-.20	4.51	5	1	63.04	.29	4.66	5	1
80 XINI/EBII	163.89	.45	4.99	23	3	1989.15	1.12	8.69	40	17	244.42	-1.58	5.13	14	0	33.99	-.10	3.73	17	3	611.15	1.06	6.08	43	18
81 DR / CR	78.67	.88	4.36	8	5	93.16	1.00	4.39	14	5	32.80	-.27	3.95	5	3	49.77	.30	4.13	5	2	53.74	.68	4.09	3	5
82 CL / CR	141.49	1.16	4.39	10	3	14.85	-.25	2.75	2	1	60.27	.70	3.45	4	2	91.08	.97	3.97	6	3	31.01	-.54	3.10	2	1
83 XINV / CL	74.07	.91	4.11	8	5	194.49	1.57	6.26	10	2	31.58	-.41	3.95	5	2	31.45	.27	3.91	3	2	78.62	.97	4.58	9	2

Appendix 5.8

Ratio Distribution Statistics for the Manufacturing
Sample (1977)

RATIO	UNTRANSFORMED					RECIPROCAL					LOG					SQUARE ROOT					SQUARE ROOT OF RECIP				
	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B
TOTAL ASSETS	1088.89	2.68	9.48	15	4	317.71	1.81	6.21	10	2	91.72	.61	3.19	4	3	555.59	1.91	5.88	13	6	111.43	.85	3.51	4	2
TOTAL NETWORTH	1135.59	2.61	9.18	17	5	269.34	1.55	5.45	5	1	98.28	.72	3.23	3	2	547.38	1.86	5.77	15	5	60.71	.61	3.11	3	1
AV. TOTAL CAPEMP	996.60	2.85	10.98	12	2	392.18	1.59	4.79	17	9	87.65	.77	3.13	2	2	551.90	1.91	5.88	15	6	92.07	.84	3.49	3	2
AV. NET. CAP EMP	1032.14	2.73	9.93	15	4	401.21	1.72	5.30	14	9	75.12	.74	3.08	2	2	595.37	1.90	5.87	14	6	124.39	.90	3.61	2	2
SALES	975.64	2.77	10.29	13	3	389.77	1.58	4.95	20	10	108.69	.77	3.27	1	1	583.63	1.91	5.99	13	5	92.84	.84	3.53	7	5
1 FF / S	23.86	.44	3.77	4	3	268.39	1.46	7.30	4	1	30.50	-.31	3.67	6	4	16.99	.05	3.45	7	5	60.42	.68	4.40	4	2
2 FF / AVTCE	20.91	.34	3.72	4	3	83.14	.99	4.80	6	1	24.73	-.28	3.77	4	1	11.43	.03	3.66	4	3	45.90	.65	4.17	4	1
3 FF / AVTA	17.08	-.00	3.56	2	2	201.30	1.62	7.09	6	1	40.21	-.69	3.97	6	3	23.01	-.35	3.57	4	4	100.68	1.10	5.14	6	1
4 VA / S	8.30	.06	3.34	2	1	364.04	1.89	8.80	9	1	60.97	-.93	4.06	9	4	25.46	-.47	3.66	4	2	124.61	1.19	4.90	12	3
5 VA / AVTA	18.92	.43	3.49	4	2	171.48	1.22	5.59	7	1	20.97	-.44	3.60	8	3	9.58	-.07	3.47	4	3	64.16	.76	4.19	7	1
6 VA / AVTCE	53.15	.74	3.85	6	3	173.39	1.19	5.21	8	1	25.21	-.34	3.92	5	4	20.24	.21	3.46	5	4	58.25	.73	3.98	7	2
7 VA / AVNCE	51.43	.75	3.82	8	5	162.56	1.14	4.77	11	2	18.03	-.35	3.56	5	4	28.69	.25	3.62	5	4	57.90	.77	3.99	7	3
8 EBIT / S	35.06	.46	4.01	8	3	539.63	2.24	14.30	4	1	21.37	-.17	3.90	6	5	21.97	.14	3.76	8	5	66.53	.63	4.71	6	2
9 EBIT/AVTA	26.76	.02	3.63	4	4	247.92	1.73	7.93	4	1	34.31	-.70	4.24	6	3	21.64	-.33	3.78	4	4	115.52	1.14	5.52	5	1
10 EBIT/AVTCE	41.29	.34	3.86	6	4	78.64	.94	5.01	4	1	33.34	-.20	3.97	4	1	25.82	.05	3.83	5	4	44.40	.56	4.27	4	1
11 VA / ER	739.22	2.60	17.00	7	3	33.67	-.46	4.06	8	1	81.87	.87	4.17	13	7	141.37	1.17	5.02	13	6	87.82	-.85	4.97	8	1
12 PBT / S	36.69	.40	4.00	9	3	246.21	1.45	8.58	4	1	21.21	-.13	4.09	8	4	23.06	.08	4.17	6	4	100.11	.73	5.84	5	1
13 PBT / AVTA	23.54	.02	3.63	3	3	137.62	1.36	6.26	5	1	26.47	-.61	4.03	5	3	20.18	-.32	3.77	3	3	69.48	.95	4.92	5	1
14 PBT/AVTNH	28.11	.13	4.32	8	4	42.59	.19	4.73	6	1	37.92	-.01	4.73	5	1	38.69	.10	4.75	5	1	40.60	.12	4.77	5	1
15 PBT/AVTL	74.79	.84	3.98	4	4	941.57	3.55	24.65	4	1	18.68	-.28	3.78	5	4	40.52	.25	3.72	5	5	107.78	.94	5.08	6	2
16 PBT/AVCL	52.50	.56	3.46	2	2	327.36	2.09	9.67	7	2	21.40	-.50	3.71	7	4	25.61	.01	3.44	5	4	106.02	1.10	5.21	8	2
17 PBT/AVTCE	38.03	.29	3.84	6	3	49.41	.72	4.53	4	1	22.30	-.14	3.93	3	1	30.23	.08	3.84	4	3	32.87	.44	4.14	3	1
18 PBT/AVNCE	36.45	.16	4.09	5	3	45.25	.27	4.28	4	1	40.67	-.01	4.33	3	1	38.75	.05	4.10	5	2	43.38	.12	4.22	4	1
19 INI / S	36.31	.13	4.17	8	5	202.97	1.29	8.33	5	1	29.73	-.20	4.23	9	4	24.14	-.05	4.05	10	5	104.87	.67	5.72	8	1
20 INI/AVTA	23.16	-.28	3.83	5	3	149.10	1.29	5.97	6	1	47.76	-.70	4.34	6	2	28.59	-.49	4.03	5	4	98.08	.98	5.03	5	1
21 XNI/AVNH	52.97	-.13	4.19	6	2	63.25	.35	4.66	5	1	58.28	-.25	4.42	6	1	52.74	-.18	4.35	6	1	59.71	.28	4.59	5	1
22 INI/AVTL	64.39	.53	4.16	1	1	1381.11	5.33	47.09	3	1	30.98	-.28	3.72	6	3	40.84	.12	3.78	4	3	67.90	.76	4.50	6	2
23 INI/AVCL	42.52	.29	3.59	2	2	555.37	2.63	14.90	4	1	29.21	-.49	3.72	7	4	28.74	-.14	3.55	4	4	158.99	1.19	6.15	5	1
24 INI/AVTCE	32.17	.06	3.93	3	3	65.55	.73	4.56	5	1	38.59	-.33	4.06	4	1	27.80	-.17	3.95	3	3	42.04	.54	4.32	4	1
25 INI/AVNCE	33.44	-.09	4.09	5	3	56.92	.46	4.60	4	1	40.35	-.24	4.35	4	1	39.04	-.14	4.29	4	1	50.54	.35	4.46	4	1

Appendix 5.8 (contd)

RATIO	UNTRANSFORMED					RECIPROCAL					LOG					SQUARE ROOT					SQUARE ROOT OF RECIP				
	CHISO	SKW	KUR	A	B	CHISO	SKW	KUR	A	B	CHISO	SKW	KUR	A	B	CHISO	SKW	KUR	A	B	CHISO	SKW	KUR	A	B
26 CF / S	24.95	.86	4.57	2	2	63.17	1.42	7.07	4	1	11.18	-.18	4.32	3	1	19.45	.18	4.49	2	1	26.21	.70	4.87	4	1
27 CF/AVTA	16.42	.48	3.85	0	0	231.05	3.13	15.92	4	1	6.66	-.71	4.30	4	2	7.54	-.28	3.96	2	2	62.90	1.65	7.73	4	1
29 CF / AVTL	47.12	.79	3.31	1	1	745.52	5.38	36.03	2	1	7.63	-.64	3.98	4	2	19.05	-.09	3.73	1	1	41.65	1.34	5.79	5	2
30 CF / AVCL	38.87	.77	3.53	0	0	202.10	2.88	14.05	4	1	9.63	-.62	3.97	4	2	15.34	-.04	3.51	1	1	48.25	1.39	6.40	5	1
31 CF / AVTCE	30.13	.66	4.41	0	0	63.17	1.65	7.81	4	1	13.74	-.41	4.24	3	1	16.35	-.02	4.25	1	1	26.63	1.02	5.57	3	1
32 CF / AVNCE	34.53	.24	4.30	0	0	371.00	4.23	27.17	3	1	14.64	-.54	4.38	3	2	24.48	-.08	3.68	3	3	105.58	1.83	9.98	3	1
33 OSCF/AVOSE	39.36	.45	4.64	1	1	433.50	4.68	31.30	3	1	19.27	-.41	4.75	4	2	26.87	.12	4.10	4	3	127.17	1.87	10.90	3	1
34 DR / CA	23.61	.18	2.52	0	0	370.31	2.25	6.84	9	4	75.37	-1.33	4.29	0	0	25.54	-.51	2.66	0	0	166.54	1.90	5.54	6	4
35 DR / XINV	114.87	2.07	7.24	5	2	323.88	2.18	6.50	8	4	30.15	-.34	3.92	0	0	31.99	1.10	4.51	4	2	113.01	1.64	4.83	7	4
36 CA / CL	27.64	1.09	4.35	3	1	19.49	.62	3.55	0	0	3.06	.32	3.24	1	1	10.76	.79	3.88	1	1	7.09	.13	3.17	1	1
37 FA / TA	22.44	.59	2.92	0	0	88.20	1.69	5.17	8	4	24.75	-.74	3.47	0	0	5.67	-.02	2.66	0	0	58.11	1.41	4.77	3	2
38 WC / TNW	8.56	-.49	3.04	1	1	33.81	.98	3.85	1	1	16.30	-.73	3.35	1	1	11.91	-.61	3.18	1	1	21.32	.85	3.58	1	1
39 WC / TL	34.06	1.20	4.56	4	1	797.48	5.08	34.00	2	1	22.03	-.72	4.24	4	2	9.72	.37	3.95	1	1	70.26	1.62	5.84	4	2
40 TA / ER	462.69	4.02	24.09	2	1	16.76	.62	3.51	4	4	31.01	.74	4.10	3	2	57.36	1.45	5.39	3	2	16.42	.03	4.33	2	1
41 WC / XNCE	5.05	-.41	2.94	1	1	25.33	.91	3.74	1	1	11.97	-.65	3.24	1	1	10.97	-.53	3.07	1	1	20.44	.78	3.47	1	1
42 WC / DR	77.23	.59	5.85	10	7	284.04	1.18	14.56	3	1	209.18	.41	11.14	6	1	81.44	.44	6.25	10	6	221.79	-.27	12.71	3	1
43 AVWC / S	35.89	.85	3.28	2	2	70.30	1.35	5.03	4	1	15.81	-.33	3.55	1	1	12.06	.29	3.14	2	2	26.22	.87	3.93	3	1
44 TL / TNW	52.88	1.43	4.70	5	3	51.00	1.32	4.46	4	2	5.92	.09	4.24	0	0	18.28	.94	3.88	3	3	15.03	.78	3.69	3	2
45 TL / TA	3.38	.03	2.97	0	0	51.00	1.32	4.46	4	2	17.57	-.31	3.60	2	2	6.81	-.46	3.34	1	1	27.96	1.04	3.83	4	2
46 DEBT / QA	97.39	1.74	6.36	5	2	692.29	3.07	10.28	12	10	101.53	-1.82	6.80	0	0	16.55	.61	3.72	3	2	218.84	2.36	7.11	13	10
47 EBIT/AVTL	53.13	1.18	4.33	2	2	299.56	3.68	19.75	4	1	21.34	-.44	4.22	5	2	29.71	.27	4.02	2	2	87.92	1.64	8.01	5	1
48 TA / TNW	52.88	1.43	4.70	5	3	3.38	-.03	2.97	0	0	18.71	.87	3.63	3	2	35.74	1.14	3.95	5	3	7.64	-.59	3.74	0	0
49 QA / TNW	25.45	1.07	4.26	2	2	269.84	2.74	9.95	10	3	49.62	-1.23	5.10	0	0	11.92	.16	3.47	1	1	119.21	2.00	6.71	10	3
50 CA / TNW	33.05	1.20	4.86	7	2	67.88	1.77	6.15	8	4	15.94	-.23	4.36	1	1	11.61	.77	4.54	2	2	33.62	1.39	5.67	2	2
51 CL / TNW	68.47	1.57	5.54	5	2	53.78	1.35	4.35	4	3	7.59	.12	4.28	0	0	18.76	.94	4.04	4	2	21.49	.77	3.51	4	3
52 AVTNW / S	41.88	1.24	4.21	6	4	95.59	1.60	5.03	4	2	15.38	-.17	2.83	0	0	20.82	.76	3.58	2	2	48.30	1.03	3.68	1	1
53 DEBT / TNW	146.96	1.39	4.50	4	1	665.00	2.95	9.84	14	10	70.81	-1.51	5.30	0	0	27.87	.52	3.01	1	1	194.07	2.13	6.15	14	10
54 DEBT/ICE	73.75	.53	2.72	0	0	654.03	2.95	9.83	14	10	121.91	-1.94	6.49	0	0	29.63	-.36	2.38	0	0	253.36	2.20	6.38	14	10
55 CA / TL	42.54	1.14	4.41	4	1	26.32	.79	3.74	4	3	16.85	.25	3.62	1	1	26.32	.77	3.93	2	1	20.66	.32	4.31	0	0

Appendix 5.8 (contd)

RATIO	UNTRANSFORMED					RECIPROCAL					LOG					SQUARE ROOT					SQUARE ROOT OF RECIP				
	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B	CHISQ	SKW	KUR	A	B
56 AVCR/COS	36.44	1.02	4.09	3	2	76.53	1.33	4.21	4	2	18.31	-.30	3.21	0	0	19.41	.48	3.59	0	0	34.98	.96	3.81	1	1
57 COS/AVINV	83.87	1.78	6.06	7	4	30.53	1.09	4.03	2	2	5.47	.66	3.68	4	4	27.59	1.23	4.41	6	4	6.48	.32	3.60	1	1
58 AVQA/PDOE	46.69	1.13	3.93	3	2	201.96	2.11	6.63	7	4	25.82	-.83	4.04	1	1	16.39	.41	3.01	2	2	72.97	1.52	4.77	6	4
59 AVQA / S	41.57	1.14	4.10	3	2	178.00	2.05	6.22	7	5	34.11	-.80	3.96	1	1	20.20	.37	3.12	2	1	72.73	1.51	4.74	6	4
60 AVQA / S	38.79	.77	2.92	2	1	76.93	1.38	4.44	4	3	17.01	-.15	2.96	0	0	11.54	.38	2.66	1	1	36.47	.92	3.82	0	0
61 S / AVFA	90.48	1.54	4.87	3	2	73.39	1.50	4.58	7	4	11.29	-.05	3.45	0	0	26.08	.88	3.59	2	1	29.02	1.04	3.87	4	3
62 S / AVTA	51.81	1.33	4.52	4	2	27.53	.92	3.39	4	3	4.07	.19	3.14	0	0	23.62	.90	3.77	1	1	6.35	.52	3.16	2	2
63 S / AVTCE	82.40	1.54	4.79	7	3	43.51	1.15	3.87	5	4	12.77	.25	3.03	0	0	35.89	1.15	4.19	1	1	9.44	.70	3.71	1	1
64 S / AVNCE	94.13	1.56	4.61	5	4	40.51	1.21	4.16	5	3	7.61	.23	2.87	0	0	41.92	1.11	3.98	1	1	9.11	.72	3.62	1	1
65 S / AVINV	81.73	1.78	6.10	7	4	27.69	1.00	3.80	2	2	11.59	.70	3.73	4	4	28.92	1.25	4.48	6	4	10.43	.22	3.52	1	1
66 DAYS DEBTORS	46.17	1.15	4.12	2	1	309.15	2.43	8.12	9	4	48.66	-.97	4.01	0	0	18.39	.33	2.72	1	1	116.57	1.77	5.47	8	4
67 QA / CL	13.72	.57	3.66	2	1	227.49	2.40	8.14	7	3	42.67	-1.13	4.72	5	3	11.30	-.23	3.88	1	1	98.66	1.83	6.13	6	3
68 QA / TL	11.64	.69	3.63	2	1	165.06	2.28	7.63	7	3	27.24	-.92	4.19	5	4	13.98	-.02	3.81	1	1	72.47	1.71	5.74	5	3
69 WC / XINV	17.44	.51	4.50	3	1	56.32	1.14	4.96	3	1	28.44	-.46	4.48	2	1	14.14	.02	4.03	3	2	44.66	.77	4.51	4	1
70 XINV / CA	17.63	.03	3.09	0	0	122.08	2.11	7.89	6	1	32.83	-1.16	4.66	3	2	15.42	-.62	3.74	1	1	59.44	1.49	5.35	6	2
71 QA-CL/PDOE	32.16	-.33	5.32	4	2	106.11	1.64	8.06	5	1	60.00	-.88	6.21	6	1	33.34	-.41	5.40	6	2	73.30	1.05	7.18	5	1
72 EDIV/OSE1	26.93	.78	3.88	3	1	175.24	2.24	6.68	14	10	80.32	-2.05	7.71	0	0	17.38	-.24	3.64	1	1	83.69	1.72	4.96	14	10
73 EDIV/OSNI	40.60	-.03	4.63	15	3	97.87	.40	4.94	23	10	59.72	-1.14	3.80	21	10	40.43	-.49	4.02	13	3	37.24	.26	3.99	23	10
74 CL / TA	7.51	.21	3.11	0	0	52.95	1.29	4.22	5	3	12.86	-.73	3.52	3	2	10.92	-.36	3.45	0	0	32.55	1.03	3.73	4	3
75 QA / TA	6.28	.15	2.81	0	0	298.23	2.51	8.30	10	4	50.00	-1.53	5.01	4	3	23.49	-.68	3.39	0	0	127.70	2.01	6.32	10	4
76 CA / TA	22.32	-.59	2.92	0	0	93.74	1.73	5.15	8	6	54.03	-1.45	5.12	0	0	24.82	-.99	3.75	0	0	65.61	1.55	4.95	8	3
77 DEBT / TA	81.02	.68	3.05	1	1	569.18	2.86	9.32	14	10	103.67	-1.71	5.53	0	0	24.80	-.27	2.38	0	0	268.87	2.16	6.14	14	10
78 DEBT / CA	56.46	1.10	4.08	3	2	701.56	3.02	10.23	14	10	98.96	-1.82	6.12	0	0	16.37	.07	2.94	0	0	220.71	2.25	6.60	14	10
79 TNI / AVTNW	26.56	.12	4.34	3	3	745.59	6.32	24.74	2	1	33.28	-.67	5.22	3	2	16.23	-.21	4.31	3	3	255.88	3.49	22.32	3	1
80 XINT/EBIT	105.19	.44	4.79	10	2	290.60	.78	7.05	17	6	70.97	-1.38	4.04	7	0	13.23	-.29	3.52	9	1	215.28	.74	5.21	17	6
81 DR / CR	67.21	.88	4.08	2	1	320.72	1.94	6.65	9	5	51.69	-1.12	4.42	1	0	21.48	.01	3.02	2	1	141.45	1.53	5.16	8	4
82 CL / CR	67.59	1.14	4.36	5	2	12.80	-.18	2.44	1	0	18.88	.54	3.22	1	0	47.64	.92	3.95	2	1	13.59	-.47	2.68	1	0
83 XINV / CL	11.32	.96	4.26	6	5	73.67	1.76	6.13	7	3	23.90	-.65	4.42	3	2	22.20	.38	4.81	0	0	32.94	1.25	4.89	6	3

Appendix 5.8 (contd)

Notes: 1. Key to Transformations

Recip = Reciprocal. The other transformations are self-explanatory.

2. Key to Statistics

CHISQ = Chisquare; SKW = Skewness; KUR = Kurtosis;

A = the number of observations beyond 3.5 standard deviations of the initial mean.

B = the number of observations set at 3.0 standard deviations of the mean computed after excluding extreme observations (equal in number to A above). See paragraph 5.7.5 for further discussion of data modifications and the statistics.

3. For key to the ratios see Appendices 5.4 and 5.5

4. Similar statistics were calculated for both manufacturing and distribution samples for the other five years but are not presented here.

Appendix 5.9.

Transformations applied to Manufacturing and Distribution data used in
Factor and Discriminant Analysis

<u>Ratio</u>	<u>Transformation</u>	<u>Ratio</u>	<u>Transformation</u>
1. TOT.ASS	Log	(32). CF/ATA	-
2. TNW	Log	33. CF/ATL	Log
3. A.TCE	Log	34. CF/ACL	Log
4. A.NCE	Log	35. CF/ATCE	SQRT
5. SALES	Log	36. CF/ANCE	SQRT
6. FF/S	SQRT	37. OSCE/AOSE	SQRT
7. FF/ATCE	SQRT	38. DR/CA	-
8. FF/ATA	SQRT	39. DR/INV	Log
(9). VA/S	-	40. CA/CL	Log
10. VA/ATA	SQRT	41. FA/TA	SQRT
11. VA/ATCE	SQRT	42. WC/TNW	-
(12). VA/ANCE	Log	(43). WC/TL	Log
13. EBIT/S	Log	44. TA/ER	SQRT
14. EBIT/ATA	SQRT	45. WC/NCE	-
(15). EBIT/ATCE	SQRT	(46). WC/DR	Log
16. VA/ER	REC	47. AWC/S	Log
17. PBT/S	Log	48. TL/TNW	Log
18. PBT/ATA	SQRT	49. TL/TA	-
19. PBT/ATNW	SQRT	50. DEBT/QA	SQRT
20. PBT/ATL	Log	51. EBIT/ATL	Log
(21). PBT/ACL	SQRT	52. TA/TNW	REC
(22). PBT/ATCE	SQRT	(53). QA/TNW	Log
23. PBT/ANCE	SQRT	54. CA/TNW	Log
(24). TNI/S	SQRT	55. CL/TNW	Log
25. TNI/ATA	-	56. ATNW/S	Log
26. NI/ANW	-	57. DEBT/TNW	SQRT
27. TNI/ATL	Log	(58). DEBT/TCE	-
28. TNI/ACL	SQRT	59. CA/TL	Log
(29). TNI/ATCE	-	(60). ACr/COS	SQRT
30. TNI/ANCE	-	61. COS/AINV	SQRT
31.	Log	(62). AQA/PDOE	Log

63. AQA/S	SQRT	76. DIV/OSEI	SQRT
64. ACA/S	SQRT	77. DIV/OSNI	-
65. S/AFA	Log	78. CL/TA	SQRT
66. S/ATA	Log	79. QA/TA	SQRT
67. S/ATCE	Log	80. CA/TA	-
68. S/ANCE	Log	81. Debt/TA	-
69. S/AINV	SQRT	82. Debt/CA	SQRT
70. DaysDrs	-	83. TNI/ATNW	-
71. QA/CL	Log	84. INT/EBIT	SQRT
72. QA/TL	Log	85. Dr/Cr	SQRT
73. WC/INV	SQRT	86. CL/Cr	REC
74. INV/CA	-	87. INV/CL	SQRT
75. SA-CL/PDOE	SQRT		

Notes: 1) Key to transformations: Log = logarithm; SQRT = Square root; SQREC = Square root of Reciprocal; REC = Reciprocal; - means no transformation.

- 2) The "best" transformations (see Paragraph 5.7.11) were the same for both manufacturing and distribution samples except in the case of ratios circled in the above list. The "best" transformations for the distribution sample was SQRT in the case of ratios 9, 12, 29, 32, 43, 46, 53, 58, 62, 70 to 72 and 81, Log in the case of 15, 21, 22, 24, 60 and 64, none in the case of 73, 75, 78 and 79.
- 3) Although in the case of the size measures - ratios 1 to 5 - SQREC was the "best" transformation logarithmic transformation has been widely used in the literature (e.g., Whittington 1980 a). Since neither log nor SQREC transformation resulted in normality and there was little difference between the two (see Appendix 5.8), following the precedent in the literature log transformation was applied to the size measures.

Appendix 6.1.

Principal Components Analysis (PCA) ¹

PCA aims at reducing the number of dimensions necessary to describe a given data domain without sacrificing too much of the information contained in that domain. Let X be a data matrix of order $n \times m$ where n is the number of observations and m the number of variables. In our case n is the number of companies and m the number of ratios, the variables. X describes the n observations in a coordinate system with m axes or directions. Looking at it another way, we may say that the m variables lie in a space of n observations.

We may picture in the latter case m vectors (one for each variable) in a space of n dimensions, denoted by S_n . However, to describe m vectors or their interrelation we would only need m dimensions. Thus the subspace S_m within S_n is adequate for describing the m vector relationships.

In the subspace S_m again we may find a set of orthogonal vectors and project the m vectors onto these vectors. If "fortuitously" projections of some of these m vectors on the new set are zero leaving, say, p nonzero projections the smaller set of p new vectors is sufficient to give a complete description of m vectors. That is, without any loss of information we are able to reduce the number of dimensions necessary to capture the data in the domain from m to p . This is the principle of parsimony and is the pre-eminent objective of factor analysis.

We said the discovery of the $(m-p)$ dimensions on which the m vector variables have zero projections could be fortuitous. However, more correctly, it is determined by the nature of the data, that is, the correlations among the m variables. For example if two variables are highly correlated a single common or "source variable" can explain the variance in both variables and there is reduction of dimensionality from 2 to 1. Similarly in the m dimensional case p "source" variables could explain all the variance in the m variables.

1. The presentation here is based on Rummel (1970), Harman (1976) and Nie et al (1975).

If the nature of the data is such that there is no zero projection then $p = m$. However in practice we may find $(m-p)$ near zero projections and we may be able to ignore these and still work with p dimensions. Here parsimony is not without loss of information but the loss is negligible. In PCA the p vectors are called components and parsimony is achieved by disregarding those components which explain variance in variables less than an arbitrary cut-off point.

To make the mathematical derivation simple the data matrix X is standardised and rescaled by factor $1/n$ with the result that $(X' X)/n$ represents the correlation matrix of m variables. The advantage of this data transformation is that each variable has unit variance and its correlation with another vector is given by its projection on the latter. The squared projection gives its variance explained by the second vector.

Since variance of each variable is unity the total variance in the data set is m , the number of variables. Since projections (and hence the squared projections) of these variables on some axes (or directions) of the new coordinate system are zero, the squared projections in some other directions will exceed unity so that the total sum of squared projections is equal to m . Thus we may find a direction in which the variance is maximum and then another direction with the next maximum and so on. The directions will, therefore, explain diminishing variance with the last ones accounting for practically zero variance.

The objective of PCA is to find these new dimensions or directions and the correlations between these unobserved dimensions and the observed variables. These correlations constitute the component, or more widely, factor matrix or factor loading matrix. Since the new set of coordinates is also located in the same space as the m variables they are linearly dependent on these variable vectors and can be expressed as linear combinations of these.

If the new coordinates are represented by m y -vectors in an $n \times m$ matrix Y then,

$$Y = X G \quad (A6.1)$$

where G is the $m \times m$ matrix of coefficients (also called factor score coefficients, since Y , the factor score matrix is derived through G) subject to the condition of orthogonality of the coordinates, $Y'Y = I$, the identity matrix.

If R is the observed correlation matrix we may find eigenvectors as column vectors in a matrix F and eigenvalues matrix Q to satisfy the equation

$$R F = F Q \quad (A6.2)$$

where F is the $m \times m$ matrix of projections of the observed variables X on the coordinates Y and Q is the diagonal matrix of order $m \times m$ giving the sums of these squared projections on the m coordinates of Y . Since $F'F$ represents these squared projections

$$F'F = Q \quad (A6.3)$$

and substituting in A6.2 we get

$$R = F F' \quad (A6.4)$$

The relation between G of A6.1 and F is given by

$$G = F Q^{-1} \quad (A6.5)$$

In the computer package used by us F is given as factor matrix and G as matrix of factor score coefficients. Although F is of rank m where R is of rank m , we may retain only those eigenvectors or factor loadings in F that correspond to eigenvalues or variances in excess of a certain cut-off point.

Rotation of factors: The solution we have obtained above, that is, the factor loading matrix F is not unique because we may find any number of coordinate sets Y in the m - space and corresponding to each there is one F . This indeterminacy is fundamental to PCA and other factor analytic methods. It means that what is the best set of coordinates Y is a decision external to the analysis. These infinite sets of coordinates are found by rotating the initial solution in the m -space. The final solution is so chosen as to satisfy criteria laid down by the analyst.

Rotation of the initial components is nothing but a linear transformation of the form

$$K = F B \quad (A6.6)$$

where $B'B = I$ to satisfy the orthogonality condition and K the new rotated factor matrix (of order $m \times p$, if we have only p components in the initial solution). In arriving at K we will aim at simplifying variable complexity (= the number of components on which a variable loads) and factor complexity (= the number of variables loading on a factor).

We want the rotation to give the observed variable vector maximum projection on a few components and minimum projection on the rest. It can be shown that this criterion will lead to the requirement that we find a transformation matrix B in such a way that the sum of the fourth powers of all elements in the resulting matrix K has a maximum. It can be shown that this can be achieved by maximising $\sum \sum k^4$ where k is an element of the factor loading matrix K.

Varimax Rotation: In this solution developed by Kaiser we maximise $\sum \sum (\frac{k}{h})^4$ where h^2 is the sum of squared loadings of a variable on the components and represents the communality of the variable. The advantage is that the solution will not be unduly affected by variables with large communality.

Oblique Factors: The difference between orthogonal and oblique factors is shown in the figures "a" and "b" below in the two dimensional case.

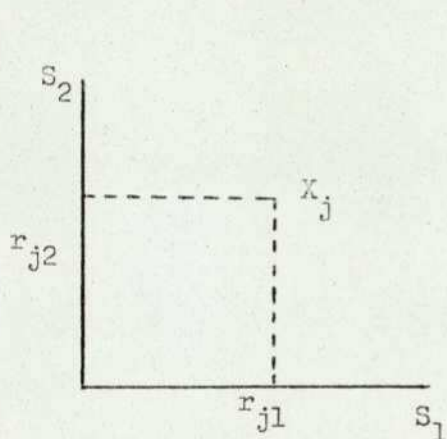


Fig. a

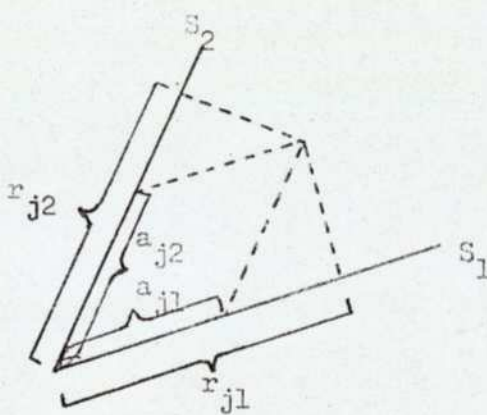


Fig. b.

The r'_j s represent the projections and coordinates in the orthogonal case whereas in the oblique case the projections are represented by r'_j s but the coordinates by a'_j s. In the place of a single factor matrix giving projections and coordinates in the case of orthogonal factors we will, therefore, have two matrices (1) the factor pattern matrix of coordinates and (2) the factor structure matrix of projections. The sum of squared projections from the structure matrix will, however, not add up to unity unlike in the orthogonal case.

The relation between coordinates and projections is given by

$$S = M C \quad (A6.7)$$

where S is the factor structure matrix of projections and M the factor pattern matrix of coordinates and C is the matrix of cosines between axes.

All the three are $m \times m$ matrices. For an orthogonal system $C = I$ and $S = M$. If the new non-orthogonal factors are given by T then

$$T'T = C \quad (A6.8)$$

If F is the orthogonal factor matrix then

$$S = FT \quad (A6.9)$$

and

$$M = SC^{-1} = FT C^{-1} \quad (A6.10)$$

Primary and Reference Axes: The oblique axes we have described above are called "primary oblique factors" or "primaries" having been obtained by rotation to best oblique fit to the configuration of variables in space. In addition, there are "reference factors" consisting of axes perpendicular to each of the primaries. These were devised by Thurstone (See Harman, 1976, ch. 13) to achieve simple structure. The different factor matrices are compared below:

	Ortho gonal	Primary pattern structure	Reference pattern structure
Loadings distinguish clusters of interrelated variables	yes	yes	no
Loadings measure correlation between cluster and variable	yes	no	yes

(From Rummel (1970), p. 148)

Direct Oblimin: The objective of oblique rotation is to make the primary factor pattern satisfy the simple structure principles. While other methods of oblique rotation like oblimax, biquartimin etc. solve this problem by simplifying the reference structure matrix, direct oblimin directly simplifies the primary pattern matrix. It minimises a function of the primary pattern coefficients in the following expression

$$F(m) = \sum_{p < q=1}^m \left(\sum_{j=1}^n a_{jp}^2 a_{jq}^2 - \frac{\delta}{n} \sum_{j=1}^n a_{jp}^2 \sum_{j=1}^n a_{jq}^2 \right) \quad (A6.11)$$

where a 's are the factor pattern loadings. The smaller the expression the more oblique the solution is (See Harman, 1976).

For certain positive values of δ $F(M)$ approaches $-\infty$. So for practical purposes Harman (1976) recommends that it be zero or negative. When it is set to zero the factors are most oblique and for its negative values they become less and less oblique. In our study δ was set to zero the default value in the SPSS programme.

Simple Structure: All along we have maintained simple structure of our matrices as our goal. One could intuitively grasp what it means. However, it was Thurstone who gave explicit and objective expression to this intuitive concept. For the criteria of simple structure see Harman (1976, Ch. 6.). There have been several attempts at quantifying these criteria, the most popular being Varimax used in this study.

As noted above the primary pattern matrix distinguishes variable clusters much more clearly than the primary structure matrix. In our study the purpose of oblique rotation was to examine whether ratio clusters were indeed orthogonal or not and to compare the ratio clusters derived from orthogonal and oblique rotations. For this reason in the presentation of our PCA results in Chapter 6 we focus on the pattern matrices rather than structure matrices.

Appendix 6.2

Varimax-rotated Orthogonal Component Loadings (Manufacturing Sample)

Dimension	Ratio	1972	1973	1974	1975	1976	1977
Profitability (FFT)	FF/ATA	.92	.90	.89	.88	.83	.89
	FF/ATCE	.90	.88	.87	.81	.86	.85
	EBIT/ATA	.90	.89	.88	.90	.88	.97
	EBIT/ATC	.92	.83	.87	.79	.85	.86
	PBT/ATA	.92	.87	.89	.89	.86	.89
	PBT/ATCE	.90	.84	.87	.79	.81	.85
	PBT/ANCE	.83	.89	.85	.84	.81	.85
	PBT/ATNW	.87	.87	.84	.82	.81	.84
	TNI/ATA	.89	.92	.92	.90	.89	.90
	TNI/ATCE	.85	.87	.87	.91	.87	.91
	TNI/ANCE	.86	.91	.86	.90	.87	.91
	TNI/ATNW	.87	.89	.86	.89	.83	.90
	NI/ANW	.87	.86	.87	.89	.85	.91
	CF/ATA	.78	.81	.86	.88	.85	.84
	CF/ATCE	.80	.84	.86	.85	.88	.89
	CF/ANCE	.76	.82	.80	.83	.85	.87
	OSCF/AOSE	.70	.75	.71	.75	.82	.81
	EBIT/ATL	.73	.67	.77	.79	.70	.71
	PBT/ATL	.73	.65	.78	.79	.73	.75
	TNI/ATL	.71	.65	.78	.82	.74	.76
	CF/ATL	.64	.62	.73	.78	.72	.73
	PBT/ACL	.72	.61	.72	.78	.70	.74
	TNI/ACL	.70	.65	.76	.81	.69	.75
	CF/ACL	.61	.55	.72	.76	.69	.73
	FF/S	.73	.63	.73	.74	.70	.69
	EBIT/S	.76	.60	.69	.76	.69	.76
	PBT/S	.78	.63	.76	.80	.72	.75
	TNI/S	.69	.60	.73	.80	.75	.70
	CF/S	.61	.51	.70	.73	.71	.75

- contd

Appendix 6.2 (contd)

Long Term Solvency ₂ (LTS)	Debt/TA	-.92	-.93	-.90	-.76	-.61	-.78
	Debt/TCE	-.91	-.93	-.86	-.86	-.75	-.69
	Debt/TNW	-.92	-.92	-.86	-.86	-.72	-.69
	Debt/CA	-.86	-.86	-.83	-.75	-.56	-.71
	Debt/QA	-.84	-.85	-.79	-.72	-.52	-.71
	TL/TNW	-.75	-.75	-.65	-.91	-.97	-
	TL/TA	-.75	-.75	-.65	-.90	-.97	-
	TNW/TA ⁶	.75	.75	.62	.90	.97	-
	CA/TL ¹	.71	.69	.57	.83	.76	-
	QA/TL ¹	.68	.67	.53	.80	.61	-
	Int/EBIT	-.68	-.69	-.61	-.57	-	-
	WC/INV	-	-	-	.69	.57	-
	WC/TL	-	-	-	.85	.81	-
	WC/Dr	-	-	-	.59	.59	-
	AWC/S	-	-	-	.54	.57	-
	CA/CL	-	-	-	.76	.78	-
	QA/CL	-	-	-	.73	.58	-
	(QA-CL)/PDOE	-	-	-	.57	.54	-
	CL/TA	-	-	-	-.74	-.88	-
	CL/TNN	-	-	-	-.85	-.96	-
Short Term Solvency ₂ (STS)	CL/TA	-.58	-.55	-.58	-	-	-.90
	CL/TNW ¹	-.50	-.47	-.50	-	-	-.95
	WC/INV	.79	.76	.80	-	-	.58
	WC/TL ¹	.77	.67	.80	-	-	.80
	WC/Dr	.73	.66	.69	-	-	.61
	AWC/S	.72	.66	.73	-	-	.54
	CA/CL	.85	.79	.85	-	-	.78
	QA/CL	.77	.76	.74	-	-	.57
	(QA-CL)/PDOE	.72	.72	.62	-	-	.57
	TL/TNW	-	-	-	-	-	-.93
	TL/TA	-	-	-	-	-	-.93
	TA/TNW	-	-	-	-	-	.94
	CA/TL	-	-	-	-	-	.67
	QA/TL	-	-	-	-	-	.55

- contd

Appendix 6.2 (contd)

Trade Creditors ³ (TCr)	Cr/CL ⁶	.88	.78	.82	.75	.79	.38
	Dr/Cr	-.66	-.77	-.74	-.77	-.62	-
Turnover (TO)	ATNW/S ⁴	.47	.50	.52	.52	.68	.74
	ACr/COS	.57	.59	.66	.61	.55	.58
	AQA/S	.85	.85	.85	.86	.66	.78
	AQA/PDOE	.89	.86	.81	.82	.70	.76
	Days Drs	.77	.83	.85	.83	.70	.73
	ACA/S	.74	.72	.85	.75	.85	.88
	S/ATA	-.68	-.69	-.76	-.75	-.88	-.92
	S/ATCE ⁴	-.54	-.56	-.55	-.58	-.75	-.77
	S/ANCE ⁴	-.49	-.50	-.51	-.54	-.75	-.74
	FA/TA	-.85	-.87	-.85	-.91	-.93	-.92
Short Term Asset Intensity (STAI)	S/AFA	.79	.81	.81	.86	.69	.72
	CA/TA	.85	.87	.85	.89	.92	.93
	CA/TNW ⁴	.79	.78	.86	.75	.55	.58
	WC/TNW ⁴	.45	.46	.46	.69	.88	.90
	WC/NCE ⁴	.48	.47	.45	.69	.89	.89
	QA/TNW ⁴	.70	.75	.73	.63	.30	.33
	Dr/CA ⁴	.65	.76	.77	.79	.52	.69
Structural Liquidity (SL)	Dr/INV	.83	.86	.85	.91	.77	.86
	QA/TA ⁴	.53	.51	.64	.57	.82	.80
	AINV/S ⁶	-.83	-.80	-.76	-.80	-.58	-.64
	AINV/S ⁶	-.83	-.80	-.76	-.78	-.58	-.61
	INV/CA	-.90	-.88	-.92	-.87	-.89	-.90
	INV/CL	-.71	-.79	-.69	-.76	-.53	-.56
	QA/TNW ⁵	.43	.42	.50	.53	.59	.61
	(QA-CL)/PDOE ⁵	.33	.28	.41	.28	.60	.59
Labour Intensity (LI)	VA/S	.58	.65	.62	.66	.65	.66
	VA/ATA	.81	.84	.86	.85	.86	.84
	VA/ATCE	.72	.73	.79	.79	.82	.79
	VA/ANCE	.53	.64	.74	.72	.79	.77
	ER/VA ⁶	.65	.68	.58	.58	.67	.65
	ER/TA ⁶	.85	.86	.84	.83	.89	.85

- contd

Appendix 6.2 (contd)

Size	Total Assets	.95	.93	.94	.94	.95	.95
	TNW	.95	.96	.94	.96	.96	.96
	TCE	.94	.94	.95	.96	.96	.96
	NCE	.95	.95	.95	.96	.97	.94
	Sales	.95	.95	.94	.95	.95	.95
Dividend	DIV/OSEI	.53	.72	.62	.59	.68	.62
Payout (DP)	DIV/OSNI	.78	.80	.76	.85	.84	.82
Cumulative Variance (%) explained		87.4	87.2	87.8	87.2	85.7	87.9

1. These ratios had average secondary loadings of about 0.55 on the other solvency dimension in 1972-74. The other ratios included in both solvency dimensions had average secondary loadings on the other solvency dimension of about 0.30 in those years.
2. In 1975 and 1976 there was virtually no split between LTS and STS, all ratios other than (QA-CL)/PDOE loading primarily on one component.
3. This dimension merged with LTS in 1977 (See Table 6.2).
4. Loadings shown include secondary loadings in some years. To simplify presentation primary loadings in those years were omitted.
5. This ratio is included in two components in order to facilitate comparison with the oblique components in Appendix 6.3 and the distribution sector dimensions in Appendix 6.4.
6. Reciprocal transformed ratios. See Appendix 5.9 for transformations applied to the other ratios.

All the above loadings are statistically significant at less than 1% level of significance using the Burt-Banks formula (see Child, Appendix C, pp.97-100).

The formula is:

$$\text{Standard Error (SE) of loading} = (\text{SE of the loading treated as a correlation coefficient}) \times \sqrt{\frac{n}{n+1-r}}$$

where n = number of variables and r = the factor number for which significance level is calculated.

In our case for the tenth factor r = 10

$$n = 87$$

$$\text{sample size } N = 570$$

$$\text{SE of loading} = .115 \text{ (approximately from Child, Appendix B)} \times \sqrt{\frac{87}{87+1-10}} = .12$$

This means that for the tenth factor the loading should be at least .12 for it to be significant at the 0.01 level. In the case of the earlier components the loadings may be less in order to be significant at this level.

Appendix 6.3

Oblique Pattern Loadings (Manufacturing Sample)¹

Dimension	Ratio	1972	1973	1974 ²	1975	1976	1977 ²
Pre-tax ³ Return on Assets (Pre-tax ROA)	FF/S	.42	.52	.73	.60	.49	.58
	FF/ATA	.82	.42 ^s	.87	.53	.65	.68
	FF/ATCE	.83	.40 ^s	.85	.80	.58	.59
	EBIT/S	.48	.74	.70	.46	.47	.61
	EBIT/ATA	.88	.62	.87	.71	.61	.67
	EBIT/ATCE	.86	.54	.85	.86	.61	.57
	PBT/S	.51	.72	.76	.65	.48	.56
	PBT/ATA	.83	.61	.84	.55	.71	.63
	PBT/ATCE	.85	.42 ^s	.82	.83	.75	.52
	PBT/ANCE	.57	.33 ^s	.82	.83	.71	.59
	PBT/ATNW	.63	.27 ^s	.84	.75	.69	.63
	EBIT/ATL	.48	.45	.71	.42	.57	.49
	PBT/ATL	.43 ^s	.44 ^s	.71	.40	.57	.50
	PBT/ACL	.27 ^s	.41	.68	.39	.56	.53
	TNI/S	.14 ^s	.49	.73	-	-	.69
Post-tax ³ Return on Assets (Post-tax ROA)	TNI/ATNW	.53	-	.89	-	-	.90
	NI/ANW	.52	-	.89	-	-	.93
	TNI/ATL	.33 ^s	-	.72	-	.31 ^s	.68
	TNI/S ⁴	.56	.29 ^s	.73	.70	.64	.69
	TNI/ATA	.59	.70	.90	.74	.71	.89
	TNI/ATNW ⁴	.41 ^s	.87	.89	.66	.89	.90
	TNI/ATCE	.57	.66	.87	.70	.76	.83
	TNI/ANCE	.55	.80	.88	.70	.86	.91
	NI/ANW ⁴	.41 ^s	.88	.89	.75	.91	.93
	TNI/ATL ⁴	.27 ^s	.37 ^s	.72	.71	.44	.68
	TNI/ACL	.49 ^s	.54	.72	.74	.61	.69
	CF/ATA ⁵	-	.84	.85	.87	.77	.94
	CF/ATCE ⁵	-	.81	.84	.89	.73	.91
	CF/ANCE ⁵	-	.83	.82	.91	.92	.98
	OSCF/AOSE ⁶	-	.94	.76	.88	.89	.95
	CF/ATL ⁶	-	.64	.68	.84	.56	.73
	CF/ACL ⁶	-	.57	.68	.86	.50	.76
	CF/S ⁶	-	.46	.71	.89	.51	.85

- contd

Long Term ⁷ Solvency (LTS)	PL/TNW	-.66	-.67	-.68	-.70	-.73	-.51
	TL/TA	-.66	-.67	-.67	-.69	-.73	-.51
	TNW/TA ⁸	.66	.67	.63	.69	.73	.50
	Debt/TA	-.98	-1.00	-.98	-.95	-.61	-.98
	Debt/TCE	-.97	-.95	-.92	-.93	-.66	-.93
	Debt/TNW	-.93	-.94	-.92	-.93	-.63	-.93
	Debt/CA	-.90	-.90	-.86	-.86	-.55	-.90
	Debt/QA	-.87	-.88	-.82	-.81	-.49	-.88
	CA/TL	.62	.55	.52	.58	.55	.40
	QA/TL	.60	.56	.46	.54	.40 ^s	.44
Short Term ⁷ Solvency (STS)	CL/TNW	-.39 ^s	-.39 ^s	-.50	-.51	-.64	-.36 ^s
	INT/EBIT	-.68	-.63	-.62	-.50	-	-
	CA/CL	.72	.71	.67	.50	.32 ^s	.48
	WC/TL	.59	.52	.53	.35 ^s	.23 ^s	.45
	WC/Dr	.49 ^s	.64	.50	.36 ^s	.28 ^s	.49
	WC/INV	.57	.80	.73	.69	.66	.71
	AWC/S	.62	.56	.58	.35 ^s	.26 ^s	.47
	QA/CL	.61	.72	.71	.74	.80	.63
	(QA-CL)/PDOE	.53	.74	.64	.85	.75	.71
	CL/TA	-.56	-.53	-.55	-.43	-.30 ^s	-.40 ^s
Trade Creditors ⁷ (TCr)	Dr/Cr	-.92	-.92	-.89	-.84	-.74	-.81
	Cr/CL ⁸	.86	.75	.86	.77	.78	.62
Turnover (TO)	ATNW/S	.41 ^s	.41 ^s	.49	.72	.38 ^s	.66
	ACr/COS	.55 ^s	.70	.75	.35 ^s	.75	.69
	AQA/S	.85	.79	.83	.52 ^s	.68	.75
	AQA/PDOE	.88	.80	.79	.55	.70	.72
	Days Drs	.65	.86	.86	.30 ^s	.80	.79
	ACA/S	.73	.66	.83	.44 ^s	.76	.89
	S/ATA	-.68	-.64	-.74	-.86	-.62	-.86
	S/ATCE	-.49 ^s	-.48 ^s	-.52	-.78	-.43	-.66
	S/ANCE	-.45 ^s	-.41 ^s	-.46	-.78	-.44	-.63
	FA/TA	-.87	-.86	-.91	-.78	-.90	-.92
Short Term Asset Intensity (STAI)	S/AFA	.78	.77	.79	.42 ^s	.82	.78
	CA/TA	.87	.85	.91	.77	.88	.93
	CA/TNW	.69	.66	.68	.41 ^s	.58	.64
	QA/TNW	.56	.62	.53	-	.34 ^s	.41 ^s
	WC/TNW	.47 ^s	.49 ^s	.62	.83	.74	.81
	WC/NCE	.57 ^s	.54	.67	.82	.78	.79

- contd

Structural Liquidity (SL)	Dr/CA	.21 ^s	.71	.81	.70	.95	.85
	Dr/INV	.51 ^s	.85	.88	.67	.77	.92
	QA/TA	.52 ^s	.53	.67	.48	.27 ^s	.74
	AINV/S ⁸	-.77	-.82	-.75	-	-.30 ^s	-.59
	AINV/COS ⁸	-.83	-.83	-.75	-	-.33 ^s	-.59
	INV/CA	-.83	-.91	-.92	-.41 ^s	-.31 ^s	-.84
	INV/CL	-.51	-.79	-.71	-.38 ^s	-.48	-.64
Labour Intensity (LI)	VA/S	.61	.69	.65	.69	.70	.66
	VA/ATA	.84	.87	.88	.90	.90	.85
	VA/ATCE	.75	.75	.80	.82	.83	.80
	VA/ANCE	.54	.65	.76	.75	.80	.77
	ER/VA ⁸	.67	.70	.57 ^s	.59	.67	.67
	ER/TA ⁸	.89	.89	.86	.87	.90	.87
Size	Total Assets	.99	.97	.97	.97	.97	.98
	TNW	1.00	1.01	1.00	1.00	.99	1.00
	TCE	.98	.98	.98	.98	.98	.99
	NCE	.98	.99	.98	.99	.98	.96
	Sales	1.01	1.00	.98	.98	.99	.98
Dividend	DIV/OSEI	.50	.80	.66	.67	.72	.74
Payout (DP)	DIV/OSNI	.87	.81	.80	.89	.91	.77

1. The components derived were required to be fairly oblique. This was achieved by setting the angle of rotation parameter δ in the SPSS programme to zero, (see Appendix 6.1 and also Nie et al, 1975).
2. In these years there was no split between Pre-tax and Post-tax ROA. The loading shown against Post-tax ROA are those of the constituent ratios on Pre-tax ROA.
3. The component pattern correlations between Pre-tax and Post-tax ROA were: .59 (1972), .51 (1973), .57 (1975) and .60 (1976).
4. This ratio is also shown under Pre-tax ROA to facilitate comparison over time.
5. This ratio loaded primarily on Pre-tax ROA in 1972.
6. This ratio loaded primarily on Dividend Payout in 1972.
7. The pattern correlations between LTS and STS were: .37 (1972), .47 (1973), .45 (1974), .42 (1975), .28 (1976) and .43 (1977). For the correlation between LTS and TCr and that between STS and TCr see Table 6.3 in the body of the thesis.
8. Reciprocal transformed ratios. See Appendix 5.9 for transformations applied to the other ratios. S indicates secondary loadings. These are shown in the place of or in addition to the primary loadings on

Appendix 6.3 (contd)

other components in order to facilitate comparison over time of the same ratio or to examine the temporal stability of the clusters.

9. - indicates very small loadings (.20)

Appendix 6.4

Varimax-rotated Temporal Comparison of Orthogonal Component Loadings
(Distribution Sample)¹

Dimension	Ratio	1972	1973	1974	1975	1976	1977
Profitability (PFT)	FF/ATA	.90	.91	.92	.91	.90	.67
	FF/ATCE	.93	.86	.92	.81	.86	.66
	EBIT/ATA	.81	.89	.90	.91	.90	.67
	EBIT/ATCE	.94	.86	.91	.72	.84	.72
	PBT/ATA	.87	.91	.89	.90	.88	.64
	PBT/ATCE	.90	.73	.91	.72	.84	.69
	PBT/ANCE	.94	.67	.90	.74	.85	.66
	PBT/ATNW	.91	.64	.91	.89	.85	.67
	TNI/ATA	.81	.89	.94	.87	.91	.84
	TNI/ATCE	.87	.84	.94	.92	.84	.75
	TNI/ANCE	.91	.65	.94	.92	.87	.79
	TNI/ATNW	.90	.68	.94	.86	.80	.83
	NI/ANW	.84	.58	.93	.93	.88	.83
	CF/ATA	.80	.82	.88	.83	.86	.93
	CF/ATCE	.85	.61	.91	.90	.81	.91
	CF/ANCE	.79	.56	.88	.87	.83	.91
	OSCF/AOSE	.68	.42	.83	.83	.77	.86
	EBIT/ATL	.63	.65	.72	.71	.73	.67
	PBT/ATL	.67	.76	.74	.79	.75	.74
	TNI/ATL	.67	.75	.80	.84	.78	.83
	CF/ATL	.54	.71	.78	.77	.77	.81
	PBT/ACL	.52	.71	.70	.75	.70	.71
	TNI/ACL	.50	.69	.77	.81	.74	.81
	CF/ACL	.54	.64	.75	.81	.74	.88
	FF/S ^s	.44	.53	.52	.56	.54	.63
	EBIT/S ^s	.46	.55	.55	.55	.59	.65
	PBT/S ^s	.54	.55	.66	.65	.70	.71
	TNI/S ^s	.52	.63	.74	.73	.72	.81
	CF/S ^s	.45	.55	.69	.72	.69	.85

- contd

Short Term Solvency (STS)	TL/TNW	-.87	-.93	-.88	-.85	-.83	-.92
	TL/TA	-.95	-.93	-.89	-.86	-.87	-.93
	TNW/TA ⁴	.95	.93	.89	.86	.87	.93
	CA/TNW	-.70	-.91	-.89	-.86	-.87	-.84
	CL/TNW	-.92	-.94	-.91	-.89	-.87	-.95
	CL/TA	-.83	-.90	-.90	-.86	-.88	-.93
	DEBT/TNW ²	-.59	-.60	-.47	-.46	-.48	-.52
	DEBT/TCE ²	-.66	-.66	-.50	-.46	-.50	-.53
Long Term Solvency (LTS)	DEBT/TNW ^s	-.50	-.53	-.69	-.54	-.58	-.72
	DEBT/TCE ^s	-.56	-.57	-.61	-.60	-.65	-.73
	DEBT/TA	-.66	-.69	-.69	-.70	-.77	-.85
	DEBT/CA	-.59	-.66	-.67	-.67	-.72	-.81
	DEBT/QA	-.50	-.54	-.60	-.61	-.60	-.68
	Cr/CL ⁴	.76	.75	.60	.72	.72	.73
Turnover (TO)	AQA/PDOE ^s	.61	.63	.56	.61	.61	.56
	AQA/S ^s	.62	.63	.57	.62	.63	.57
	VA/S	.83	.75	.71	.69	.73	.68
	ATNW/S	.75	.73	.58	.71	.73	.64
	ACr/COS	.61	.69	.78	.74	.74	.75
	AINV/COS ^{3,4}	.71	.75	.83	.87	.84	.76
	AINV/S ^{3,4}	.63	.73	.81	.81	.83	.76
	ACA/S	.80	.82	.80	.85	.85	.80
	S/AFA ^{2,3}	-.58	-.57	-.44	-.46	-.51	-.51
	S/ATA	-.92	-.91	-.82	-.85	-.88	-.86
	S/ATCE	-.81	-.79	-.68	-.73	-.76	-.74
	S/ANCE	-.79	-.76	-.60	-.67	-.70	-.68
	Days Drs ^s	.54	.59	.54	.57	.57	.56
Size	Total Assets	.97	.97	.98	.98	.98	.98
	TNW	.94	.94	.95	.96	.95	.94
	TCE	.94	.94	.96	.97	.97	.96
	NCE	.94	.95	.96	.97	.97	.96
	Sales	.96	.95	.95	.94	.93	.94

- contd

Short Term Asset Intensity (STAI)	CA/CL ³	.86	.88	.88	.89	.82	.82
	PA/TA	-.77	-.70	-.66	-.55	-.63	-.72
	CA/TA	.78	.71	.68	.56	.64	.72
	CA/TL ³	.84	.86	.85	.68	.78	.82
	WC/TNW	.86	.89	.83	.89	.84	.83
	WC/TL ³	.87	.85	.89	.90	.82	.75
	WC/NCE	.91	.91	.83	.83	.79	.86
	WC/Dr ³	.58	.69	.74	.34	.58	.55
Structural Liquidity (SL)	WC/INV ³	.50	.62	.74	.77	.59	.51
	AWC/S ³	.72	.75	.80	.62	.70	.71
	S/AFA ³	.49	.53	.37	.36	.37	.44
	Dr/CA	.82	.81	.89	.86	.88	.87
	Dr/INV	.89	.86	.94	.90	.92	.89
	QA/CL	.65	.59	.79	.74	.76	.76
	QA/TL	.68	.61	.77	.77	.80	.80
	INV/CA	-.94	-.92	-.96	-.96	-.97	-.93
Labour Intensity (LI)	INV/CL	-.72	-.81	-.63	-.57	-.58	-.57
	(QA-CL)/PDOE	.61	.52	.55	.47	.49	.66
	QA/TNW	.59 ^s	.55 ^s	.67	.62	.66	.62
	Dr/Cr ³	.60	.59	.76	.75	.77	.75
	QA/TA	.74	.69	.84	.85	.88	.82
	VA/ATA	.77	.73	.80	.77	.84	.80
	VA/ATCE	.58	.57	.63	.59	.71	.69
	VA/ANCE	.59	.53	.61	.68	.61	.66
Dividend Payout (DP)	ER/VA ⁴	.72	.58	.57	.41	.53	.42
	ER/TA ⁴	.95	.85	.92	.91	.86	.91
Cumulative Variance (%) explained	DIV/OSEI	.71	.51	.58	.57	.59	.53
	DIV/OSNI	.85	.76	.82	.89	.78	.90
Cumulative Variance (%) explained		87.9	87.0	91.5	84.5	85.8	86.1

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1. All the loadings shown here are statistically significant at less than the 1% level of significance calculated using the Burt-Banks formula (see note to Appendix 6.2 for details of the formula).
2. Means that the ratio is included in two components in order to facilitate comparison with the components of the manufacturing sample.
3. Means that the ratio loads on a different component from that in the case of the manufacturing sample.
4. Reciprocal transformed ratios. See Appendix 5.9 for transformation applied to the other ratios.
5. Indicates secondary loadings in the year indicated or in all years. Secondary loadings are shown to facilitate comparison with the manufacturing sample results as well as over time.

All the loadings shown above are significant at the 0.01 level. At this level, on the basis of the Burt-Banks formula (see Appendix 6.2) the minimum loading should be approximately 0.182 for the ninth component with $r = 9$, $n = 87$ and $N = 201$.

Appendix 6.5

Comparison of Factor Analytic Studies of Financial Ratios

	Present Study ⁴	Taffler (1977)	Comparable Dimension ^{***} in Pinches (1973 & 75) ^{**}	Johnson (1979)	Laurent (1979)
D I M E N S I O N	1. PFT	Profitability	ROI ¹	ROI	ROI
	2. LTS	FL ²	FL	FL	Gearing, LTS & Standing Charges Cover
	3. STS	Working Capital	ST ³ Liquidity	ST Liquidity	STS
	4. TCr	Creditors Position	*	*	*
	5. TO	Activity	Capital Turnover	Capital Intensive-ness	**
	6. STAI	*	**	Inventory Intensive-ness	Fixed Asset Management
	7. SL	Current Asset Breakdown	Receivables T'over & Inventory T'over	Receivables Intensive-ness	Inventory Management & Credit Policy
	8. LI	Value Added	*	*	*
	9. Size	*	*	*	*
	10. DP	*	*	*	*
a	11	7	7	8	10
b	87%	93.5%	92%	82%	89.7%
c	UK	UK	USA	USA	Hong Kong
d	both	Manufacturing	Manufacturing	both	NA
e	570 & 201	92	221	306 & 159	63
f	87	80	48	61	45
g	PCA OR & OB	PCA OR	Factor OB	PCA OR	PCA OR
h	1972-77	1974-75	1951-69	1972 & 74	NA
i	6 years	not studied	4 & 20 years	3 years	not studied

- contd

1. ROI = Return on Investment.
 2. FL = Financial Leverage.
 3. ST = Start Term.
 4. = See Appendix 6.2 for key to the abbreviations.
- * - ratios representing this dimension were not included in the study.
- ** - this dimension not identified by the study although ratios representing it in our study or similar ratios were included.
- *** - this study includes ratios not represented in our study.
- a - number of dimensions extracted; b - cumulative variance explained;
c = country of data; d = manufacturing/distribution sample analysed;
e = sample size; f = number of ratios; g = methodology - Principal components or factor analysis with orthogonal (OR) or oblique (OB) rotation; h = period of study; i = period over which stability of dimensions studied. NA = not available.

The purposes of discriminant analysis are:

- 1) to test for mean group differences and
- 2) to construct classification schemes based upon a set of m variables in order to assign previously unclassified observations to the appropriate groups.

As a procedure for testing for significant differences among groups means discriminant analysis is basically the multivariate extension of univariate analysis of variance.

Investigating Group Differences: The significance tests for this purpose in both the two - and k -group cases are formed assuming multivariate normality² of the discriminating variables and common dispersions among the groups. When the dispersions are unequal the associated significance tests are only approximate.

2-group case: Suppose we wish to test for the significance of the difference between the means of two groups with sample sizes N_1 and N_2 based on a variable vector X' of which x_i , $i=1, \dots, m$ are the elements the multidimensional data can be transformed into a unidimensional data by an appropriate discriminant function of the form

$$y = b_1 x_1 + b_2 x_2 + \dots + b_m x_m \quad (A7.1)$$

The b 's are chosen so as to maximise the ratio of the weighted between groups variance to the pooled within-groups variance of y . The variance ratio maximised is

$$E = \frac{(N_1 N_2)}{(N_1 + N_2)} \frac{B'dd'B}{B'S_w B} \quad (A7.2)$$

where $d = (\bar{X}_1 - \bar{X}_2)$, $\bar{X}_1$ and $\bar{X}_2$ = group mean vectors

-
1. The presentation here is based on Eisenbeis and Avery (1972) and page references in this Appendix are to this source unless stated otherwise.
 2. See paragraphs 7.4.5 to 7.4.8 for a discussion of the validity of this assumption in our study.

B = Vector of discriminant coefficients, b_i in equation A7.1

and S_w = pooled within groups dispersion matrix. An element of S_w is

$$(S_w)_{ij} = \frac{1}{N_1 + N_2 - 2} \sum_{g=1}^2 \sum_{n=1}^{N_g} (x_{gin} - \bar{x}_{gi})(x_{gjn} - \bar{x}_{gj}) \quad (A7.3)$$

where x_{gi} is the i^{th} element of X_g , g = group number and $N_g = N_1 + N_2$

We may derive from equation A7.2 (p.8)

$$E = \frac{N_1 N_2}{N_1 + N_2} d' S_w^{-1} d \quad (A7.4)$$

where $d' S_w^{-1} d$ is the Mahalanolis D^2 statistic.

Assuming multivariate normal populations and equal group dispersion matrices E can be used to form the test statistic:

$$\frac{N_1 + N_2 - m - 1}{N_1 + N_2 - 2} \frac{1}{m} E$$

which has an approximate F distribution with m and $(N_1 + N_2 - m - 1)$ degrees of freedom. The null hypothesis of equality of group mean vectors can be rejected when the value of the test statistic is greater than the tabled value of F for a given level of significance (p.8).

k-group case: The two-group theory may be readily extended to the k-group case. In the latter case we need to find the set of $(m \times 1)$ vectors $V_1, V_2, \dots, V_r$ which maximise the ratio

$$E_2 = \frac{|V'QV|}{|V'WV|} \quad (A7.5)$$

where $V_{m \times r} = \begin{pmatrix} V_1 & V_2 & \dots & V_r \\ m \times 1 & m \times 1 & \dots & m \times 1 \end{pmatrix}$

and Q is the matrix of the weighted among-groups deviation sums of squares of X and W is the matrix of pooled within-groups deviation sum of squares. V is the matrix of r discriminant functions coefficients and must be chosen so as to maximise E_2 .

This maximisation problem can be solved by finding the eigen vectors associated with the roots of the determinantal equation, $|Q - \lambda W| = 0$ where W is assumed to be of full rank and positive definite and λ_i are the associated eigen values with $i = 1, 2, \dots, r$. The number of discriminant functions is determined by the rank of Q which is equal

to the minimum of m and $k-1$. Then V is the matrix of eigen vectors associated with the non-zero roots which will maximise E_2 . V represents a linear transformation from the original m -dimensional variable space to the r -dimensional discriminant space. Variation among the groups in discriminant space is greatest in the dimension (the first discriminant function) associated with λ_1 , next greatest in the dimension associated with λ_2 , etc. Thus the discriminatory power of the discriminant functions progressively diminishes from the first to the r^{th} function.

The eigen values may be used to form the Wilk's lambda statistic which can then be used to form tests of significance of group mean differences (p.10).

$$\text{Wilk's lambda} = \Lambda = \frac{|W|}{|T|} = \prod_{t=1}^r \frac{1}{1 + \lambda_t} \quad (\text{A7.6})$$

where T is the matrix of total deviations sum of squares.

Λ can be used to form an approximate chi-square test of group mean differences. The test statistic is

$$t = \left[\frac{m+k+2}{2} - \sum_{g=1}^k \frac{N_g}{g} \right] \ln \Lambda \quad (\text{A7.7})$$

where $\ln$ is natural logarithm.

The statistic ~~t~~ is distributed as $\chi^2_{m(k-1)}$ with $m(k-1)$ degrees of freedom and can be used to test for the significance of group mean differences.

An alternative test, RAO's F test relies on the following statistic (p.11).

$$F = \frac{1 - \bigwedge \frac{1}{c}}{\bigwedge \frac{1}{c}} \frac{dc - m(k-1)/2 + 1}{m(k-1)} \quad (\text{A7.8})$$

$$\text{where } c^2 = \frac{m^2(k-1)^2 - 4}{m^2 + (k-1)^2 - 5} \text{ and } d = \left(\sum_{g=1}^k \frac{N_g}{g} \right) - \frac{m+k+2}{2}$$

F_Λ is approximately distributed as F statistic with $m(k-1)$ and $(dc - m(k-1)/2 + 1)$ degrees of freedom where $m > 2$ and $k > 3$

Relative Discriminatory Power of Discriminant Variables:

In general no tests are available to determine the significance of a particular coefficient in a given discriminant function (p. 67). Eisenbeis and Avery suggest (p. 70) an approximate method for measuring the relative contributions of the individual variables to the total set of discriminant functions. This method consists in scaling the discriminant function coefficients by multiplying them by the square roots of the diagonal elements of the matrix W and then weighting by the respective eigen values. The ratio of each scaled-weighted coefficient to the sum of these coefficients serves as an approximate measure of the total contribution of each variable. This is the measure used in our analysis presented in Chapters 7 to 9.

Significance of Discriminant functions: For each discriminant function i the following test statistic can be formed (p. 63):

$$\left[\left(\sum_{g=1}^k N_g \right) - \frac{1}{2} (m-k) \right] \ln (1+\lambda_i) \quad (A7.9)$$

This statistic is approximately distributed as χ^2 with $(m+k-2i)$ degrees of freedom and can be used to test the significance of the i^{th} function given that the previous $(i-1)$ functions are significant. This test is, however, not exact.

Classification Procedures: Classification using discriminant analysis requires a criterion for good classification. In general, the "good classification" procedure would minimise the expected costs or, where costs of misclassification are not taken into account, the expected probability of misclassification. In the present study misclassification costs were not relevant. The function to be minimised was of the form (in the two-group case),

$$M = P(1/2) \Pi_2 + P(2/1) \Pi_1 \quad (A7.10)$$

where Π_1 , and Π_2 are prior probabilities of membership of groups 1 and 2 and $P(1/2)$ the probability of assigning an observation to group 1 given that it arose from group 2. M is minimised by the classification rule:

assign to group 1 if

$$\frac{f_1(X)}{f_2(X)} \geq \frac{\Pi_2}{\Pi_1} \quad (A7.11)$$

where f_1 and f_2 are the probability density functions of populations 1 and 2. (For estimates of prior probabilities see paragraph 7.3.4).

Linear Classification Rule: Where the assumption of dispersion equality holds the linear rule is appropriate. In that case the classification rule above can be shown to be equivalent to (p. 14):
assign to population 1 if

$$X' B_p - \frac{1}{2} (U_1' + U_2') B_p \geq \ln p \quad (A7.12)$$

where $p = \frac{\prod_2}{\prod_1}$, U_1 and U_2 are population mean vectors and B_p is the population equivalent to the sample discriminant coefficients vector. $X' B_p$ is the population equivalent to the sample discriminant function A7.1. U_1 and U_2 may be approximated by sample estimates $\bar{X}_1$ and $\bar{X}_2$ and B_p by B . Then A7.12 reduces to

$$X' B - \frac{1}{2} (\bar{X}_1' + \bar{X}_2') B \geq \ln p \quad (A7.13)$$

Testing for Equality of Dispersion Matrices: For a sample of k groups and m variables with group dispersion matrices, S_i ($i = 1, \dots, k$), pooled within-groups dispersion matrix S_w and total sample observations $N = \sum_{g=1}^k N_g$, the Box test based on an F statistic may be used to test the null hypothesis of dispersion matrices equality (E.A. Appendix IB). This test was carried out in the present study using the MULDIS programme (see paragraph 7.3.1).

Quadratic Classification Rule: If the dispersion matrices are not equal it is not appropriate to use the linear rule. The classification rule then becomes (p.16):
assign to population if

$$X'(D_1^{-1} - D_2^{-1})X - 2(U_1' D_1^{-1} - U_2' D_2^{-1})X + U_1' D_1^{-1} U_1 - U_2' D_2^{-1} U_2 \geq \ln |D_2 \cdot D_1^{-1}| - 2 \ln p \quad (A7.14)$$

where D_1 and D_2 are group population dispersion matrices. As before we may use sample estimates in the place of the population parameters which are unknown.

k-group Case

The general form of the classification rule analogous to the two-group case is (p.17):

Assign to group g if for all other groups h

$$\frac{f_g(X)}{f_h(X)} = \frac{\pi_h}{\pi_g}, \quad h = 1, 2, \dots, k \text{ and } h \neq g \quad (A7.15)$$

Classification is performed by using a set of $k(k-1)$ functions of the m variables. (For appropriate equations for the linear and quadratic rules see Eisenbeis and Avery (1972), pp.16-20).

Estimation of Classification Error Rates

As noted in paragraph 7.3.5 error rates were estimated using

- 1) the original sample (OS) method
- 2) the Lachenbruch Holdout (LH) method and
- 3) the prediction sample (PS) method.

The nature and the relative merits of these methods are briefly indicated in Section 7.5. For further details see Eisenbeis (1977).

Stepwise Discriminant Analysis

In the present study discriminant models were constructed using the stepwise procedure in the Statistical Package for the Social Sciences (SPSS) (see Nie et al, 1975). This programme provides for controlling the variables entering or remaining in the models at each step by means of the FIN and FOUT parameters. Only those variables each with multivariate partial F (which is a measure of the incremental discriminatory power of that variable) exceeding FIN was allowed to enter the models at each step. When this statistic fell below FOUT the variable was removed. In our study these parameters were set at the default value of 1 which is associated with a significance level of 0.50. This value is not very restrictive.

The number of variables in the models in our study was controlled by specifying the maximum number of steps in the stepwise procedure. In order to keep our models reasonably simple the stepwise procedure was terminated when it was found that there was little increase in the discriminatory power of the models as indicated by the decrease in Wilk's lambda.

Appendix 7.2

Analysis of Variance between Manufacturing and Distribution Firms - Univariate
F-ratios

Ratio	1972	1973	1974	1975	1976	1977
Total Assets	2.7	2.1	2.7	2.1	2.9	2.1
TNW	8.4	6.8	6.4	6.9	7.8	5.5
TCE	7.2	4.6	4.4	4.3	4.4	3.3
NCE	10.4	7.8	7.1	6.8	7.5	6.1
Sales	8.8	8.0	5.1	6.2	5.1	4.6
FF/S	81.9	100.1	103.9	92.5	108.3	98.3
FF/ATCE	22.6	11.9	.1	1.1	.7	1.3
FF/ATA	4.7	.9	4.0	1.6	7.2	5.9
VA/S	259.4	342.0	345.1	352.2	307.8	318.6
VA/ATA	42.4	56.7	84.8	65.3	63.1	66.4
VA/ATCE	6.8	11.9	28.3	20.9	25.2	32.0
VA/ANCE	.4	2.1	12.4	11.7	10.5	13.5
EBIT/S	51.2	78.3	92.6	72.9	88.6	82.8
EBIT/ATA	10.6	3.5	2.3	.5	6.2	5.0
EBIT/ATCE	29.1	16.5	.4	2.0	.7	1.2
ER/VA	73.9	53.4	22.2	24.2	10.4	10.3

Appendix 7.2 (contd)

Ratio	1972	1973	1974	1975	1976	1977
PBT/S	37.1	61.7	67.9	52.1	71.4	64.1
PBT/ATA	8.8	1.6	3.6	1.0	8.5	5.7
PBT/ATNW	40.6	21.1	.0	.2	1.8	.3
PBT/ATL	.0	2.1	7.2	3.7	12.3	8.7
PBT/ACL	1.5	5.8	12.9	6.6	17.4	11.1
PBT/ATCE	25.2	11.3	.0	.8	2.3	1.2
PBT/ANCEZ	44.6	26.0	.7	1.3	.6	.0
TNI/S	46.0	82.4	74.7	52.6	72.8	61.1
TNI/ATA	4.7	.2	6.1	.6	5.1	2.4
NI/ANW	32.3	8.8	.3	.3	.3	.3
TNI/ATL	.7	7.6	10.6	3.6	9.8	7.0
TNI/ACL	4.3	15.2	17.8	6.8	15.7	9.2
TNI/ATCE	18.9	4.2	.0	1.4	.4	.2
TNI/ANCE	36.5	12.4	.2	1.6	.0	1.0
CF/S	89.0	146.0	128.1	97.0	110.3	91.3
CF/ATA	.2	7.0	18.4	5.4	12.2	4.7
CF/ATL	6.7	23.3	26.5	13.1	20.8	13.2
CF/ACL	15.9	38.4	38.4	21.3	30.5	20.9

Appendix 7.2 (contd)

Ratio	1972	1973	1974	1975	1976	1977
CF/ATCE	9.5	.1	4.2	.0	2.7	1.2
CF/ANCE	19.2	3.2	4.4	.3	.4	.2
OSCF/AOSE	15.4	.9	4.4	.3	.9	.0
Dr/CA	5.8	10.4	11.5	6.5	10.3	13.2
Dr/INV	9.6	16.6	14.3	12.6	20.6	22.8
CA/CL	86.1	74.5	64.6	84.5	73.5	69.2
FA/TA	.8	.1	2.5	1.3	3.5	3.1
WC/TNW	35.7	47.9	52.5	58.0	61.2	53.6
WC/TL	73.7	69.0	61.1	76.4	67.5	62.3
ER/TA	92.9	81.7	75.1	68.7	45.1	61.2
WC/NCE	31.7	41.2	42.6	45.0	47.4	45.3
WC/Dr	18.3	35.9	23.2	15.6	6.9	3.9
AWC/S	157.1	144.9	123.3	146.7	151.3	148.9
TL/TNW	36.7	24.9	12.8	25.0	18.2	19.8
TL/TA	36.0	24.2	14.7	29.6	22.2	19.3
DEBT/QA	6.9	14.5	7.3	11.0	29.5	19.9
EBIT/ATL	.0	1.9	7.7	3.9	12.6	9.7
TA/TNW	36.0	24.2	14.7	29.6	22.2	19.3
QA/TNW	3.9	.0	3.0	.0	4.2	3.3

Appendix 7.2 (contd)

Ratio	1972	1973	1974	1975	1976	1977
CA/TNW	11.0	5.2	.2	3.2	1.4	2.0
CL/TNW	56.4	36.7	19.8	37.1	26.5	28.4
ATNW/S	237.8	190.8	154.6	173.1	170.6	161.6
DEBT/TNW	8.5	10.1	1.9	8.5	13.9	13.8
DEBT/TCE	7.3	8.6	2.2	10.5	15.9	13.1
CA/TL	37.1	34.4	32.5	42.1	39.5	36.9
ACr/COS	149.1	176.1	173.0	190.5	183.9	167.9
AINV/COS	181.4	173.5	161.0	190.1	167.2	147.1
AQA/PDOE	226.7	213.8	191.2	190.5	208.8	211.3
AQA/S	180.5	162.9	130.9	152.2	158.4	165.6
ACA/S	275.9	246.6	201.4	238.9	227.5	230.1
S/AFA	125.1	93.1	64.1	72.3	69.5	62.5
S/ATA	299.5	246.2	192.0	225.1	218.2	196.5
S/ATCE	258.5	205.7	161.7	181.2	172.0	149.7
S/ANCE	275.9	216.3	175.3	188.2	187.6	177.8
AINV/S	173.0	159.8	141.3	176.2	155.0	133.6
Days Drs	162.8	138.3	118.4	135.4	126.2	130.7
QA/CL	57.9	63.5	56.5	64.6	75.2	74.7

Appendix 7.2 (contd)

Ratio	1972	1973	1974	1975	1976	1977
QA/TL	31.5	41.6	39.3	41.1	54.9	54.5
WC/INV	31.1	31.5	34.4	49.7	46.6	42.3
INV/CA	.0	2.0	.3	.1	3.9	5.1
(QA-CL)/PDOE	8.9	6.3	1.7	1.2	5.2	4.9
DIV/OSE1	2.9	3.6	1.7	.3	.9	1.2
DIV/OSNI	23.5	.6	4.2	.3	.9	1.9
CL/TA	66.8	42.9	26.3	48.8	34.7	30.1
QA/TA	.2	5.2	7.0	3.7	14.2	16.3
CA/TA	.0	1.7	7.0	5.1	8.9	7.4
DEBT/TA	3.0	3.9	.8	7.2	12.9	9.3
DEBT/CA	5.1	1.8	2.4	8.3	15.3	9.8
TNI/ATNW	32.0	16.0	.2	.3	.3	.4
INT/EBIT	.1	22.7	1.9	.9	2.8	2.2
Dr/Cr	27.9	30.6	26.0	30.0	27.0	34.4
Cr/CL	8.8	1.9	6.6	13.8	18.2	8.8
INV/CL	46.4	7.9	33.2	44.5	26.1	19.4

Note

- 1) $F_{0.01}$ is approximately 6.90 with degrees of freedom as follows:
1 and 769 (1972-75), 1 & 768 (1976) and 1 & 719 (1977).

See Yeomans on ANOVA and for F table.

- 2) In general ratios relating earnings to capital employed e.g. EBIT/ATCE showed greater variation in their F ratios probably due to the variability of income and financial policies from year to year.

Appendix 7.3

Misclassified Manufacturing Firms

Firm	Sample size	As % of Turnover		Value Added Sales
		Dist	O'seas	
<u>Food & related industries</u> (49,50 & 51)	28			
Associated British Foods (50)		33	35	.17
Basset (Geo) Holdgs (49)		50		
Bibby (J) & Sons (49)		NA		
British Sugar Corporation (49)		NA		
Highgate & Job Group (49)		NA		
Feedex (49)		20		
Lyons (J) & Co (49)		NA	56	.16
Northern Foods (51)		NA		
Pauls & Whites (49)		NA		
Spillers (50)		NA	NA	
Tate & Lyle (49)		43	NA	
Unilever (49)		NA	50	.17
<u>Metallurgy</u> (32)	15			
Cohen (A.) & Co		NA	70	.08
Load Industries		NA	33	.14
Ratoliffs (Great Bridge)		NA	60	.09

Appendix 7.3(contd)

<u>General Chemicals (68)</u>	24			
Carless Capel & Leonard				
Federated Chemical Hldgs		NA	NA	
Scottish Agricultural Industries		NA		
<u>Oil (70)</u>	7			
Burmah Oil Co		NA	50	.11
Tricentrol		90	8	.17
Ultramar		NA	95	.09
<u>Holding Companies (73)</u>	46			
Bowater Corp.		56	NA	.13
Sale Tilney & Co		NA	10	.08
Wood Hall Trust		50	40	.07
<u>Transport (72)</u>	2			
National Carbonising		54		
<u>Footwear (64)</u>	11			
Allebone & Sons		85		
<u>Furnishing Stores (56)</u>	1			
Medminster		NA		
<u>Multiple Stores (58)</u>	2			
Helene of London		NA		

Note: Dist=distribution. Blanks under O'seas mean very little overseas operation. NA = data not available. Numbers within parentheses next to firms or industries are SEIC codes.

Appendix 7.4

Misclassified Distribution Firms

	<u>P & E</u> <u>Blags</u>	<u>VA/S</u>	<u>S/AFA</u>	<u>S/AINV</u>	<u>CA/CL</u>	<u>S/ATCE</u>	<u>Days</u> <u>Drs</u>
<u>Timber (17)</u>							
Brownlee & Co	.73	.20	5.34	3.68	2.00	2.02	75.84
International Timber	.38	.16	3.71	3.18	1.51	1.63	79.12
Mallinson-Denny	1.43	.12	15.80	4.17	1.53	3.25	72.81
Parker Timber	.69	.21	4.78	4.97	1.62	2.81	76.33
Phoenix Timber	.69	.18	5.22	3.87	1.23	2.60	71.00
Sabah Timber	1.19	.23	8.56	4.68	1.82	3.20	68.02
Walker (J.O.)	.98	.18	17.42	5.91	2.18	3.56	73.52
<u>Builders Merchants (13)</u>							
Cakebread, Robey	.42	.22	4.24	5.22	1.72	2.29	68.14
Leboff (S.) (Fobel)	2.14	.24	19.12	3.47	1.78	2.39	108.51
Randalls Gr (Mfg)	.12	.18	1.94	17.96	1.42	4.37	54.87
Status Discount	-	.15	1.78	5.10	.49	1.85	11.29
Travis & Arnold	.35	.20	5.29	2.63	2.29	2.44	64.70
UBM Gr.	.35	.21	6.21	6.25	1.43	2.88	72.98
<u>Special Steels (33)</u>							
Brown & Tawse	.51	.18	6.03	5.29	1.65	2.92	80.10
Firth (G.M.)	1.11	.14	7.14	5.92	1.21	3.98	62.73
Graham Wood Steel	NA	.18	4.36	4.81	1.35	2.44	73.76
Lilleshall		.22	7.16	4.76	1.42	2.53	97.66

Appendix 7.4 (contd)

	VA/S	S/AFA	S/AINV	CA/CL	S/ATCE	Days Drs
<u>Mail Order (57)</u>						
Brown (N) Investments	.18	8.88	5.20	1.08	2.23	149.11
Empire Stores	.18	16.08	7.38	2.31	2.98	109.22
Freemans (Lon)	.16	8.33	6.24	1.49	3.18	106.76
Grattan Warehouses	.18	14.57	5.31	1.88	2.87	108.49
S & U Stores	.29	3.24	5.48	1.38	1.27	184.67
<u>Department Stores (55)</u>						
Beattie James	.26	4.93	9.50	1.57	3.15	32.64
Fortnum & Mason	.27	6.54	5.98	3.39	1.55	74.20
Goldberg (A)	.32	3.09	14.29	1.58	1.55	166.95
Liberty & Co	.21	6.14	5.14	1.97	2.66	55.41
Maple & Co	.18	1.28	5.39	1.04	.69	64.06
Upton (E)	.31	2.30	7.95	1.58	1.55	82.36
Wades Department Stores	.27	4.22	5.83	1.32	2.18	16.28
<u>Furnishing Stores (56)</u>						
Allied Retailers	.23	4.60	7.17	1.12	3.25	47.83
Cantors	.20	4.14	8.94	1.24	2.85	109.57
Courts (Furnishers)	.24	3.17	7.20	1.59	1.43	168.00
Hardy & Co	.25	3.19	8.56	1.48	1.48	167.19
Henderson-Kenton	.22	5.25	7.88	1.57	2.08	142.86
Waring & Gillow	.29	6.08	4.29	1.61	3.01	50.13

Appendix 7.4 (contd)

	VA/S	S/AFA	S/AINV	CA/CL	S/ATCE	Days Drs
<u>Multiple Stores (58)</u>						
Boots & Co	.30	3.73	6.24	1.81	2.55	21.18
Burton Gr	.34	.83	4.18	1.21	.65	79.19
Combined English Stores	.25	7.52	6.39	1.43	4.19	36.33
Currys	.20	7.34	7.20	1.72	4.07	44.18
Gieves Gr	.27	5.65	7.19	1.22	2.89	50.33
Great Universal Stores	.24	6.02	7.84	2.62	1.95	128.87
Hepworth	.43	1.10	5.82	.98	.93	99.86
Moss Bros	.51	2.58	2.25	1.47	1.04	92.20
Raybeck	.26	7.58	7.40	1.12	5.43	36.34
Reed (Austin)	.28	2.44	5.09	1.50	1.51	97.11
Samuel (H.)	.39	3.57	3.84	1.79	1.81	12.85
Time Products	.23	16.11	4.13	1.59	3.83	53.96
Turner (W.E)	.30	4.32	4.18	2.53	2.50	20.62
UDS Gr	.33	1.70	9.11	1.19	1.28	79.20
Walker (James)	.18	3.24	2.13	2.18	3.56	73.52

Note: 23 of the 73 misclassified distribution firms (see paragraphs 7.7.2 and 7.7.8) have been excluded from the above analysis since they were drawn from 12 industries indicating lack of any systematic industry-related pattern.

Numbers within parentheses next to industry names are SEIC codes.

P&E = Plant & Equipment. Bldgs = Buildings. NA = data not available.

Appendix 8.1

14 - industry Linear Classification Matrices in Percent

PERCENT TABLE OF TOTAL LINEAR CLASSIFICATION

COLUMNS CORRESPOND TO PREDICTED GROUP MEMBERSHIP
ROWS CORRESPOND TO ACTUAL INPUTED GROUP MEMBERSHIP
VALUES ARE PERCENT OF TOTAL IN CLASS

Original Sample (OS) Method

1972

		PREDICTED GROUPS													1972	
	TOTAL	BLOG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT	
GROUP BLOG	100.0	48.000	4.000	4.000	4.000	20.000	4.000	8.000	0.000	4.000	0.000	0.000	0.000	4.000	0.000	
GROUP METL	100.0	13.333	13.333	13.333	13.333	13.333	6.667	6.667	6.667	0.000	6.667	0.000	0.000	6.667	0.000	
GROUP FOOD	100.0	0.000	0.000	61.905	9.524	4.762	0.000	0.000	0.000	4.762	0.000	0.000	4.762	4.762	9.524	
GROUP PACK	100.0	8.696	0.000	8.696	26.087	26.087	8.696	4.348	4.348	4.348	4.348	4.348	0.000	0.000	0.000	
GROUP CHEM	100.0	20.833	0.000	0.000	12.500	58.333	0.000	0.000	0.000	4.167	0.000	4.167	0.000	0.000	0.000	
GROUP ELEC	100.0	4.762	0.000	0.000	9.524	4.762	4.762	4.762	4.762	14.286	0.000	4.762	0.000	0.000	4.762	
GROUP INPL	100.0	5.263	0.000	10.526	0.000	5.263	26.316	36.842	5.263	5.263	0.000	0.000	0.000	5.263	0.000	
GROUP MACH	100.0	0.000	15.385	0.000	0.000	0.000	7.692	0.000	53.846	0.000	0.000	7.692	0.000	15.385	0.000	
GROUP LIEL	100.0	6.667	0.000	6.667	0.000	0.000	13.333	20.000	0.000	53.333	0.000	0.000	0.000	0.000	0.000	
GROUP MOCO	100.0	5.882	0.000	0.000	17.647	5.882	29.412	5.882	5.882	0.000	23.529	0.000	0.000	5.882	0.000	
GROUP CLTH	100.0	4.000	0.000	0.000	4.000	0.000	0.000	0.000	0.000	8.000	0.000	52.000	8.000	12.000	12.000	
GROUP WOOL	100.0	7.143	0.000	14.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14.286	50.000	14.286	0.000	
GROUP TEXT	100.0	0.000	0.000	0.000	0.000	14.286	0.000	9.524	0.000	0.000	0.000	4.762	19.048	47.619	4.762	
GROUP FOOT	100.0	0.000	0.000	18.182	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.091	0.000	18.182	54.545	
COLUMN TOTAL	100.0	10.227	1.894	9.470	8.712	11.742	10.227	6.818	4.545	6.818	2.273	7.955	6.303	9.091	4.924	

1973

		PREDICTED GROUPS													1973	
		TOTAL	BLOG	MFTL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP	BLOG	100.0	40.000	0.000	4.000	20.000	8.000	8.000	0.000	0.000	0.000	0.000	4.000	0.000	4.000	0.000
GROUP	MFTL	100.0	13.333	13.333	13.333	0.000	20.000	6.667	3.000	13.333	0.000	6.667	0.000	0.000	6.667	0.000
GROUP	FOOD	100.0	0.000	0.000	66.667	9.524	4.762	0.000	4.762	0.000	0.000	0.000	4.762	9.524	0.000	0.000
GROUP	PACK	100.0	30.435	0.000	3.000	34.783	13.043	0.000	4.348	0.000	4.348	0.000	0.000	0.000	4.348	0.000
GROUP	CHEM	100.0	12.500	0.000	4.167	16.667	5.000	0.000	0.000	0.000	4.333	0.000	0.000	4.167	0.000	0.000
GROUP	ELEC	100.0	9.524	0.000	0.000	0.000	0.000	33.333	4.762	9.524	14.286	19.048	9.524	0.000	0.000	0.000
GROUP	INPL	100.0	5.263	0.000	5.263	5.263	0.000	10.526	47.368	10.526	5.263	0.000	5.263	0.000	5.263	0.000
GROUP	MACH	100.0	6.000	15.385	0.000	0.000	0.000	7.692	7.692	23.077	15.385	7.692	23.077	0.000	0.000	0.000
GROUP	LIEL	100.0	0.000	0.000	0.000	0.000	0.000	13.333	0.000	0.000	4.000	0.000	0.000	0.000	13.333	0.000
GROUP	MOCO	100.0	5.882	0.000	5.882	0.000	0.000	23.529	0.000	5.882	0.000	47.059	0.000	0.000	5.882	0.000
GROUP	CLTH	100.0	4.000	0.000	0.000	0.000	0.000	0.000	0.000	4.000	0.000	4.000	63.000	0.000	4.000	4.000
GROUP	WOOL	100.0	0.000	0.000	7.143	0.000	7.143	0.000	0.000	0.000	0.000	0.000	14.286	50.000	21.429	0.000
GROUP	TEXT	100.0	0.000	0.000	0.000	4.762	4.762	4.762	4.762	0.000	0.000	4.762	28.571	14.286	33.333	0.000
GROUP	FOOT	100.0	9.091	0.000	18.182	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14.286	27.273	0.000	27.273
COLUMN TOTAL		100.0	10.606	2.273	8.712	8.712	9.848	7.576	6.439	5.303	6.061	6.818	13.258	6.061	6.818	1.515

1974

		PREDICTED GROUPS													1974	
GROUP	TOTAL	BLOG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT	
GROUP BLOG	100.0	56.000	0.000	0.000	16.000	8.000	8.000	0.000	0.000	4.000	4.000	0.000	0.000	4.000	0.000	
GROUP METL	100.0	6.667	13.333	20.000	6.667	26.667	0.000	6.667	0.000	0.000	6.667	6.667	0.000	6.667	0.000	
GROUP FOOD	100.0	9.524	4.762	71.429	4.762	0.000	0.000	0.000	0.000	0.000	4.762	0.000	0.000	4.762	0.000	
GROUP PACK	100.0	8.696	0.000	0.000	52.174	13.043	4.348	4.348	0.000	0.000	4.348	0.000	0.000	13.043	0.000	
GROUP CHEM	100.0	8.333	4.167	12.500	4.167	54.167	4.167	0.000	0.000	8.333	0.000	4.167	0.000	0.000	0.000	
GROUP ELEC	100.0	4.762	0.000	0.000	0.000	0.000	33.333	19.048	9.524	4.762	9.524	4.762	0.000	4.762	0.000	
GROUP INPL	100.0	5.263	0.000	0.000	10.526	5.263	52.632	10.526	0.000	0.000	0.000	5.263	0.000	5.263	0.000	
GROUP MACH	100.0	0.000	0.000	0.000	0.000	15.385	7.692	0.000	46.154	15.385	15.385	0.000	0.000	0.000	0.000	
GROUP LIEL	100.0	0.000	6.667	0.000	0.000	0.000	13.333	20.000	13.333	13.333	6.667	6.667	0.000	6.667	0.000	
GROUP MOCO	100.0	29.412	5.882	0.000	0.000	0.000	29.412	5.882	0.000	5.882	17.647	0.000	5.882	0.000	0.000	
GROUP CLTH	100.0	4.000	4.000	0.000	8.000	4.000	0.000	0.000	0.000	0.000	8.000	60.000	4.000	8.000	0.000	
GROUP WOOL	100.0	0.000	0.000	14.286	7.143	0.000	0.000	0.000	0.000	0.000	0.000	14.286	50.000	14.286	0.000	
GROUP TEXT	100.0	4.762	0.000	0.000	4.762	0.000	9.524	4.762	0.000	0.000	0.000	28.571	23.810	23.810	0.000	
GROUP FOOT	100.0	9.091	0.000	27.273	0.000	0.000	0.000	0.000	0.000	0.000	0.000	45.455	1.010	0.000	18.182	
COLUMN TOTAL	100.0	11.742	2.652	10.985	9.470	10.006	7.576	7.955	4.545	3.788	4.324	12.879	5.303	6.818	7.56	

Appendix 8.1 (contd)

Original Sample Method

PERCENT TABLE OF TOTAL LINEAR CLASSIFICATION

COLUMNS CORRESPOND TO PREDICTED GROUP MEMBERSHIP
ROWS CORRESPOND TO ACTUAL INPUTED GROUP MEMBERSHIP
VALUES ARE PERCENT OF TOTAL IN CLASS

1975

		PREDICTED GROUPS														
		BLOG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT	
GROUP	BLOG	100.0	56.000	4.000	12.000	0.000	4.000	4.000	4.000	4.000	4.000	0.000	0.000	4.000	0.000	
GROUP	METL	100.0	0.000	13.333	20.000	13.333	0.000	6.667	6.667	0.000	13.333	0.000	0.000	13.333	0.000	
GROUP	FOOD	100.0	4.762	4.762	71.429	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.762	9.524	0.000	
GROUP	PACK	100.0	26.087	0.000	0.000	39.130	8.696	4.348	8.696	0.000	4.348	0.000	0.000	4.348	0.000	
GROUP	CHEM	100.0	20.833	8.333	8.333	0.000	45.833	0.000	4.167	4.167	0.000	4.167	0.000	0.000	0.000	
GROUP	ELEC	100.0	9.524	4.762	0.000	4.762	52.381	0.000	9.524	4.762	0.000	9.524	0.000	0.000	0.000	
GROUP	INPL	100.0	5.263	0.000	0.000	5.263	21.053	42.105	5.263	5.263	5.263	0.000	0.000	0.000	0.000	
GROUP	MACH	100.0	0.000	0.000	0.000	0.000	15.385	15.385	46.154	0.000	7.692	0.000	0.000	7.692	0.000	
GROUP	LIEL	100.0	13.333	6.667	0.000	6.667	26.667	0.000	13.333	26.667	0.000	0.000	0.000	6.667	0.000	
GROUP	MOCO	100.0	11.765	0.000	5.882	17.647	5.882	0.000	0.000	0.000	11.765	0.000	5.882	0.000	0.000	
GROUP	CLTH	100.0	4.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.000	64.000	12.000	8.000	4.000	
GROUP	WOOL	100.0	0.000	0.000	7.143	0.000	0.000	0.000	0.000	0.000	0.000	42.857	35.714	14.286	0.000	
GROUP	TEXT	100.0	4.762	0.000	4.762	14.286	9.524	0.000	9.524	0.000	0.000	19.048	14.286	23.810	0.000	
GROUP	FOOT	100.0	9.091	0.000	9.091	9.091	0.000	0.000	0.000	0.000	0.000	36.364	18.182	0.000	18.182	
COLUMN	TOTAL	100.0	13.636	8.030	9.470	9.091	8.712	10.985	6.818	5.303	3.030	3.409	13.258	9.687	6.439	1.136

1976

PREDICTED GROUPS																1976	
GROUP	BLOG	TOTAL	BLOG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT	
GROUP	BLOG	100.0	32.000	0.000	4.000	24.000	16.000	0.000	0.000	4.000	0.000	4.000	0.000	0.000	0.000	0.000	
GROUP	METL	100.0	6.667	0.000	20.000	13.333	26.667	0.000	6.667	6.667	0.000	13.333	0.000	0.000	0.000	0.000	
GROUP	FOOD	100.0	0.000	4.762	71.429	14.286	4.762	0.000	0.000	0.000	0.000	0.000	0.000	4.762	9.524	0.000	
GROUP	PACK	100.0	17.331	0.000	0.000	52.174	8.696	0.000	0.000	0.000	13.043	4.348	0.000	4.348	0.000	0.000	
GROUP	CHEM	100.0	20.833	12.500	8.333	0.000	45.833	0.000	4.167	0.000	4.167	0.000	4.167	0.000	0.000	0.000	
GROUP	ELEC	100.0	0.000	0.000	0.000	0.000	47.619	19.048	0.000	14.286	0.000	4.762	0.000	4.762	0.000	0.000	
GROUP	INPL	100.0	0.000	0.000	0.000	5.263	5.263	26.316	31.579	5.263	0.000	15.789	5.263	0.000	5.263	0.000	
GROUP	MACH	100.0	0.000	7.692	0.000	0.000	7.692	7.692	15.385	7.692	15.385	7.692	15.385	7.692	7.692	0.000	
GROUP	LIEL	100.0	4.762	0.000	0.000	6.667	0.000	0.000	0.000	6.000	0.000	0.000	0.000	0.000	13.333	0.000	
GROUP	MOCO	100.0	5.882	0.000	0.000	11.765	11.765	23.529	5.882	0.000	5.882	24.412	0.000	0.000	0.000	0.000	
GROUP	CLTH	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	72.000	0.000	4.000	8.000	
GROUP	WOOL	100.0	0.000	0.000	7.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14.286	57.143	14.286	7.143	
GROUP	TEXT	100.0	4.762	0.000	4.762	14.286	9.524	0.000	14.286	4.762	4.762	0.000	19.048	0.000	28.571	0.000	
GROUP	FOOT	100.0	0.000	0.000	18.182	9.091	0.000	0.000	0.000	0.000	0.000	0.000	37.273	18.182	0.000	27.273	
COLUMN	TOTAL	100.0	7.955	2.273	9.848	11.364	11.364	7.576	7.955	2.273	8.333	5.303	12.500	4.545	6.439	2.273	

1977

		PREDICTED GROUPS														
		1977														
		TOTAL	BLOG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP	BLOG	100.0	41.667	0.000	0.000	20.833	4.167	4.167	8.333	4.167	4.167	4.167	0.000	0.000	8.333	0.000
GROUP	METL	100.0	15.385	7.692	7.692	7.692	30.769	0.000	7.692	0.000	0.000	15.385	7.692	0.000	0.000	0.000
GROUP	FOOD	100.0	0.000	0.000	70.000	10.000	0.000	0.000	10.000	0.000	0.000	0.000	0.000	5.000	0.000	5.000
GROUP	PACK	100.0	19.048	4.762	9.524	42.857	9.524	0.000	0.000	0.000	0.000	4.762	0.000	0.000	9.524	0.000
GROUP	CHEM	100.0	12.500	12.500	4.167	4.167	50.000	0.000	0.000	4.167	4.167	0.000	4.167	0.000	4.167	0.000
GROUP	ELEC	100.0	11.111	0.000	0.000	11.111	0.000	33.333	5.556	16.667	5.556	5.556	5.556	0.000	5.556	0.000
GROUP	INPL	100.0	5.556	0.000	0.000	0.000	0.000	11.111	44.444	11.111	5.556	0.000	0.000	5.556	16.667	0.000
GROUP	MACH	100.0	7.143	0.000	0.000	0.000	21.429	7.143	21.429	35.714	0.000	0.000	7.143	0.000	0.000	0.000
GROUP	LIEL	100.0	14.286	0.000	0.000	0.000	7.143	7.143	0.000	14.286	21.429	21.429	0.000	7.143	7.143	0.000
GROUP	MOCO	100.0	12.500	6.250	0.000	6.250	0.000	18.750	25.000	0.000	6.250	25.000	0.000	0.000	0.000	0.000
GROUP	CLTH	100.0	0.000	0.000	3.333	4.167	0.000	0.000	4.167	0.000	0.000	4.167	54.167	8.333	8.333	8.333
GROUP	WOOL	100.0	0.000	0.000	7.143	0.000	0.000	0.000	7.143	0.000	0.000	0.000	21.429	50.000	7.143	7.143
GROUP	TEXT	100.0	15.000	0.000	0.000	0.000	0.000	0.000	10.000	0.000	5.000	5.000	15.000	5.000	40.000	0.000
GROUP	FOOT	100.0	0.000	0.000	27.273	0.000	0.000	0.000	0.000	0.000	0.000	0.000	18.182	27.273	0.000	27.273
COLUMN	TOTAL	100.0	11.952	2.390	9.562	8.765	9.562	5.578	9.950	5.578	3.586	5.578	4.960	6.376	5.367	2.789

PERCENT TABLE OF TOTAL LINEAR CLASSIFICATION

Appendix 8.1 (contd)

COLUMNS CORRESPOND TO PREDICTED GROUP MEMBERSHIP
ROWS CORRESPOND TO ACTUAL INPUTED GROUP MEMBERSHIP
VALUES ARE PERCENT OF TOTAL IN CLASS

Lachenbruch Holdout (LH) Method

PREDICTED GROUPS

1972

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	32.000	4.000	4.000	8.000	21.000	4.000	8.000	0.000	4.000	4.000	0.000	0.000	4.000	0.000
GROUP METL	100.0	13.333	6.667	20.000	13.333	13.333	6.667	6.667	6.667	0.000	6.667	0.000	0.000	6.667	0.000
GROUP FOOD	100.0	4.762	0.000	57.143	9.524	4.762	0.000	0.000	0.000	4.762	0.000	0.000	4.762	4.762	9.524
GROUP PACK	100.0	8.696	0.000	8.696	26.087	26.087	8.696	4.348	4.348	4.348	4.348	4.348	0.000	0.000	0.000
GROUP CHEM	100.0	20.833	0.000	0.000	12.500	54.167	0.000	4.167	0.000	4.167	0.000	0.000	0.000	0.000	4.167
GROUP ELEC	100.0	4.762	0.000	0.000	14.286	4.762	38.095	9.524	4.762	9.524	0.000	0.000	0.000	0.000	4.762
GROUP INPL	100.0	5.263	0.000	10.526	0.000	5.263	31.579	31.579	5.263	5.263	0.000	0.000	0.000	5.263	0.000
GROUP MACH	100.0	0.000	15.385	0.000	0.000	0.000	30.769	0.000	23.077	0.000	0.000	7.692	7.692	15.385	0.000
GROUP LIEL	100.0	6.667	0.000	6.667	0.000	0.000	20.000	13.333	13.333	33.333	0.000	0.000	0.000	6.667	0.000
GROUP MOCO	100.0	5.882	0.000	0.000	17.647	5.882	29.412	11.765	5.882	0.000	17.647	0.000	0.000	5.882	0.000
GROUP CLTH	100.0	4.000	0.000	0.000	4.000	0.000	0.000	0.000	0.000	8.000	0.000	44.000	8.000	12.000	20.000
GROUP WOOL	100.0	7.143	0.000	14.286	0.000	0.000	0.000	0.000	14.286	0.000	0.000	14.286	7.143	42.857	0.000
GROUP TEXT	100.0	0.000	0.000	0.000	23.810	0.000	0.000	9.524	0.000	0.000	0.000	9.524	23.810	28.571	4.762
GROUP FOOT	100.0	0.000	0.000	18.182	0.000	0.000	0.000	0.000	0.000	0.000	0.000	18.182	0.000	18.182	45.455
COLUMN TOTAL	100.0	9.091	1.515	9.470	10.227	12.121	11.364	7.197	4.545	5.303	2.273	7.955	3.788	9.470	5.682

PREDICTED GROUPS

1973

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	24.000	0.000	4.000	28.000	12.000	12.000	8.000	0.000	4.000	0.000	4.000	0.000	4.000	0.000
GROUP METL	100.0	6.667	6.667	13.333	6.667	26.667	6.667	6.667	13.333	0.000	6.667	0.000	0.000	6.667	0.000
GROUP FOOD	100.0	0.000	0.000	57.143	9.524	4.762	0.000	4.762	0.000	0.000	0.000	4.762	14.286	0.000	4.762
GROUP PACK	100.0	34.783	0.000	0.000	26.087	13.043	0.000	4.348	0.000	4.348	13.043	0.000	0.000	4.348	0.000
GROUP CHEM	100.0	20.833	4.167	4.167	16.667	41.667	0.000	0.000	0.000	8.333	0.000	0.000	4.167	0.000	0.000
GROUP ELEC	100.0	9.524	0.000	0.000	0.000	0.000	28.571	4.762	9.524	14.286	23.810	9.524	0.000	0.000	0.000
GROUP INPL	100.0	5.263	0.000	5.263	5.263	0.000	10.526	36.842	10.526	5.263	5.263	5.263	0.000	10.526	0.000
GROUP MACH	100.0	0.000	15.385	0.000	0.000	0.000	15.385	7.692	15.385	15.385	7.692	0.000	0.000	0.000	0.000
GROUP LIEL	100.0	0.000	6.667	0.000	6.667	6.667	13.333	6.667	20.000	26.667	0.000	0.000	0.000	13.333	0.000
GROUP MOCO	100.0	5.882	0.000	5.882	5.882	0.000	29.412	5.882	5.882	0.000	35.294	0.000	0.000	5.882	0.000
GROUP CLTH	100.0	4.000	5.000	0.000	0.000	4.000	0.000	4.000	4.000	0.000	4.000	56.000	4.000	8.000	4.000
GROUP WOOL	100.0	0.000	0.000	7.143	0.000	7.143	0.000	0.000	0.000	0.000	0.000	21.429	42.857	21.429	0.000
GROUP TEXT	100.0	0.000	4.762	0.000	9.524	9.524	4.762	4.762	0.000	0.000	4.762	28.571	14.286	19.048	0.000
GROUP FOOT	100.0	9.091	0.000	18.182	0.000	0.000	0.000	0.000	0.000	0.000	0.000	36.364	27.273	0.000	9.091
COLUMN TOTAL	100.0	9.848	3.030	7.955	9.470	9.848	8.333	6.818	4.924	5.303	7.197	13.258	6.439	6.439	1.136

PREDICTED GROUPS

1974

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	44.000	4.000	0.000	20.000	8.000	12.000	0.000	0.000	4.000	4.000	0.000	0.000	4.000	0.000
GROUP METL	100.0	6.667	6.667	20.000	6.667	26.667	0.000	13.333	0.000	0.000	6.667	6.667	0.000	6.667	0.000
GROUP FOOD	100.0	9.524	9.524	57.143	4.762	4.762	0.000	0.000	0.000	0.000	4.762	0.000	0.000	4.762	4.762
GROUP PACK	100.0	17.391	0.000	0.000	30.435	21.739	4.348	4.348	0.000	0.000	4.348	4.348	0.000	13.043	0.000
GROUP CHEM	100.0	8.333	4.167	12.500	8.333	45.833	4.167	4.167	0.000	8.333	0.000	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	4.762	0.000	4.762	0.000	4.762	19.048	23.810	9.524	14.286	4.762	9.524	0.000	4.762	0.000
GROUP INPL	100.0	5.263	0.000	0.000	10.526	5.263	15.789	36.842	10.526	0.000	5.263	5.263	0.000	5.263	0.000
GROUP MACH	100.0	0.000	0.000	0.000	0.000	15.385	15.385	0.000	38.462	15.385	15.385	0.000	0.000	0.000	0.000
GROUP LIEL	100.0	0.000	6.667	6.667	20.000	0.000	13.333	20.000	13.333	0.000	6.667	6.667	0.000	6.667	0.000
GROUP MOCO	100.0	29.412	5.882	0.000	0.000	0.000	29.412	5.882	0.000	5.882	17.647	0.000	5.882	0.000	0.000
GROUP CLTH	100.0	4.000	4.000	0.000	8.000	4.000	0.000	0.000	0.000	0.000	8.000	56.000	4.000	12.000	0.000
GROUP WOOL	100.0	0.000	0.000	14.286	7.143	0.000	0.000	0.000	0.000	0.000	0.000	28.571	28.571	14.286	7.143
GROUP TEXT	100.0	4.762	0.000	9.524	0.000	9.524	0.000	4.762	0.000	0.000	0.000	28.571	23.810	19.048	0.000
GROUP FOOT	100.0	9.091	0.000	27.273	0.000	0.000	0.000	0.000	0.000	0.000	0.000	45.455	9.091	0.000	9.091
COLUMN TOTAL	100.0	11.364	3.330	10.227	9.091	11.364	7.955	7.955	4.167	3.409	5.303	13.636	4.545	6.818	1.136

PERCENT TABLE OF TOTAL LINEAR CLASSIFICATION

Appendix 8.1 (contd)

COLUMNS CORRESPOND TO PREDICTED GROUP MEMBERSHIP
 ROWS CORRESPOND TO ACTUAL INPUTED GROUP MEMBERSHIP Lachenbruch Holdout Method
 VALUES ARE PERCENT OF TOTAL IN CLASS

PREDICTED GROUPS

1975

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	HOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	44.000	4.000	4.000	24.000	0.000	4.000	4.000	4.000	4.000	4.000	0.000	0.000	4.000	0.000
GROUP METL	100.0	0.000	13.333	20.000	13.333	13.333	0.000	6.667	6.667	0.000	13.333	0.000	0.000	13.333	0.000
GROUP FOOD	100.0	9.524	4.762	66.667	0.000	4.762	0.000	0.000	0.000	0.000	0.000	0.000	4.762	9.524	0.000
GROUP PACK	100.0	30.435	0.000	0.000	30.435	8.696	4.348	8.696	0.000	0.000	4.348	4.348	4.348	4.348	0.000
GROUP CHEM	100.0	29.167	12.500	8.333	0.000	33.333	0.000	4.167	4.167	4.167	0.000	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	9.524	4.762	0.000	4.762	4.762	52.381	0.000	9.524	4.762	0.000	9.524	0.000	0.000	0.000
GROUP INPL	100.0	5.263	0.000	0.000	5.263	5.263	26.316	21.053	15.789	5.263	5.263	10.526	0.000	0.000	0.000
GROUP MACH	100.0	0.000	0.000	0.000	0.000	7.692	23.077	15.385	38.462	0.000	7.692	0.000	0.000	0.000	0.000
GROUP LIEL	100.0	13.333	6.667	0.000	6.667	0.000	26.667	6.667	20.000	13.333	0.000	0.000	0.000	6.667	0.000
GROUP HOCO	100.0	17.647	0.000	5.882	17.647	5.882	35.294	5.882	0.000	0.000	5.882	0.000	5.882	0.000	0.000
GROUP CLTH	100.0	4.000	0.000	0.000	0.000	4.000	0.000	0.000	0.000	0.000	4.000	56.000	12.000	12.000	8.000
GROUP WOOL	100.0	0.000	0.000	7.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	42.857	28.571	21.429	0.000
GROUP TEXT	100.0	4.762	0.000	4.762	14.286	23.810	0.000	9.524	0.000	0.000	0.000	23.810	14.286	4.762	0.000
GROUP FOOT	100.0	9.091	0.000	9.091	9.091	0.000	0.000	0.000	0.000	0.000	0.000	54.545	18.182	0.000	0.000
COLUMN TOTAL	100.0	14.394	3.409	9.091	9.470	8.712	11.742	5.682	6.061	2.273	3.930	14.015	5.682	5.682	.758

PREDICTED GROUPS

1976

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	HOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	12.000	0.000	4.000	32.000	20.000	4.000	0.000	4.000	0.000	4.000	0.000	0.000	8.000	0.000
GROUP METL	100.0	6.667	0.000	20.000	13.333	26.667	0.000	6.667	6.667	0.000	13.333	6.667	0.000	0.000	0.000
GROUP FOOD	100.0	0.000	4.762	57.143	14.286	4.762	0.000	0.000	0.000	0.000	0.000	4.762	0.000	4.762	9.524
GROUP PACK	100.0	21.739	0.000	4.348	34.783	8.696	0.000	0.000	0.000	13.043	4.348	4.348	8.696	0.000	0.000
GROUP CHEM	100.0	25.000	16.667	8.333	0.000	37.500	0.000	4.167	0.000	4.167	0.000	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	0.000	0.000	0.000	0.000	9.524	38.095	23.810	4.762	14.286	0.000	4.762	0.000	4.762	0.000
GROUP INPL	100.0	0.000	0.000	0.000	5.263	5.263	31.579	21.053	5.263	0.000	15.789	10.526	0.000	5.263	0.000
GROUP MACH	100.0	0.000	7.692	0.000	0.000	7.692	7.692	15.385	0.000	23.077	7.692	7.692	15.385	7.692	0.000
GROUP LIEL	100.0	6.667	0.000	0.000	6.667	0.000	6.667	6.667	0.000	53.333	6.667	0.000	0.000	13.333	0.000
GROUP HOCO	100.0	5.882	5.882	0.000	11.765	11.765	23.529	17.647	0.000	11.765	11.765	0.000	0.000	0.000	0.000
GROUP CLTH	100.0	0.000	0.000	0.000	4.000	0.000	0.000	8.000	4.000	0.000	0.000	52.000	8.000	12.000	12.000
GROUP WOOL	100.0	0.000	0.000	7.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	28.571	42.857	14.286	7.143
GROUP TEXT	100.0	4.762	0.000	9.524	4.762	9.524	0.000	14.286	4.762	4.762	4.762	19.048	0.000	23.810	0.000
GROUP FOOT	100.0	0.000	0.000	18.182	9.091	0.000	0.000	0.000	0.000	0.000	0.000	36.364	18.182	0.000	18.182
COLUMN TOTAL	100.0	6.818	2.652	9.091	10.606	10.985	7.955	8.333	2.273	8.712	4.924	12.500	5.303	6.818	3.930

PREDICTED GROUPS

1977

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	HOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	20.833	0.000	0.000	33.333	8.333	4.167	8.333	8.333	4.167	4.167	0.000	0.000	8.333	0.000
GROUP METL	100.0	15.385	0.000	7.692	15.385	39.769	0.000	7.692	0.000	0.000	15.385	7.692	0.000	0.000	0.000
GROUP FOOD	100.0	0.000	0.000	55.000	15.000	0.000	0.000	10.000	0.000	0.000	0.000	0.000	0.000	5.000	10.000
GROUP PACK	100.0	33.333	6.762	9.524	23.810	9.524	0.000	0.000	0.000	0.000	4.762	4.762	0.000	9.524	0.000
GROUP CHEM	100.0	12.500	16.667	4.167	8.333	33.333	0.000	0.000	8.333	8.333	0.000	4.167	0.000	4.167	0.000
GROUP ELEC	100.0	11.111	0.000	0.000	16.667	0.000	16.667	5.556	16.667	0.000	16.667	11.111	0.000	5.556	0.000
GROUP INPL	100.0	5.556	0.000	0.000	5.556	0.000	5.556	16.889	11.111	5.556	5.556	0.000	5.556	16.667	0.000
GROUP MACH	100.0	7.143	0.000	0.000	0.000	21.429	14.286	20.571	7.143	14.286	0.000	7.143	0.000	0.000	0.000
GROUP LIEL	100.0	14.286	0.000	0.000	0.000	7.143	14.286	0.000	21.429	7.143	21.429	0.000	7.143	7.143	0.000
GROUP HOCO	100.0	12.500	6.250	0.000	6.250	0.000	18.750	25.000	0.000	6.250	25.000	0.000	0.000	0.000	0.000
GROUP CLTH	100.0	0.000	0.000	9.333	4.167	0.000	0.000	8.333	0.000	0.000	4.167	45.833	12.500	8.333	8.333
GROUP WOOL	100.0	0.000	0.000	7.143	0.000	0.000	0.000	7.143	0.000	0.000	0.000	35.714	28.571	7.143	14.286
GROUP TEXT	100.0	15.000	5.000	0.000	0.000	5.000	0.000	10.000	0.000	5.000	5.000	35.000	5.000	15.000	0.000
GROUP FOOT	100.0	0.000	0.000	27.273	0.000	0.000	0.000	9.090	0.000	0.000	0.000	27.273	27.273	0.000	18.182
COLUMN TOTAL	100.0	11.155	2.749	8.367	10.359	8.367	4.741	10.359	5.179	3.586	6.773	12.749	5.578	6.773	3.187

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Appendix 8.2

14-industry Quadratic Classification Matrices in Percent

PERCENT TABLE OF TOTAL QUADRATIC CLASSIFICATION

Original Sample (OS) Method

COLUMNS CORRESPOND TO PREDICTED GROUP MEMBERSHIP
ROWS CORRESPOND TO ACTUAL INPUTED GROUP MEMBERSHIP
VALUES ARE PERCENT OF TOTAL IN CLASS

PREDICTED GROUPS

1972

GROUP	BLOG	MEYL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	HOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLOG	100.0	56.000	0.000	8.000	8.000	0.000	8.000	4.000	0.000	8.000	0.000	0.000	0.000	0.000
GROUP MEYL	100.0	6.667	33.333	6.667	6.667	0.000	13.333	0.000	0.000	13.333	0.000	0.000	13.333	0.000
GROUP FOOD	100.0	0.000	0.000	57.143	4.762	0.000	4.762	0.000	4.762	4.762	0.000	9.524	9.524	4.762
GROUP PACK	100.0	13.043	4.348	4.348	30.435	8.696	0.000	0.000	4.348	13.043	0.000	0.000	8.696	4.348
GROUP CHEM	100.0	25.000	4.167	0.000	4.167	50.000	4.167	0.000	0.000	8.333	0.000	0.000	0.000	0.000
GROUP ELEC	100.0	0.000	0.000	0.000	4.762	4.762	57.143	9.524	0.000	14.286	9.524	0.000	0.000	0.000
GROUP INPL	100.0	10.526	0.000	0.263	0.000	0.000	57.895	0.000	10.526	0.000	0.000	5.263	5.263	0.000
GROUP MACH	100.0	0.000	23.877	0.000	0.000	0.000	0.000	61.538	0.000	7.692	7.692	0.000	0.000	0.000
GROUP LIEL	100.0	6.667	0.000	6.667	6.667	0.000	13.333	6.667	60.000	0.000	0.000	0.000	0.000	0.000
GROUP HOCO	100.0	0.000	0.000	0.000	0.000	5.882	0.000	0.000	0.000	88.235	0.000	0.000	5.882	0.000
GROUP CLTH	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.000	4.000	56.000	4.000	20.000	4.000
GROUP WOOL	100.0	7.143	4.000	0.000	7.143	0.000	0.000	0.000	0.000	0.000	7.143	57.143	21.429	0.000
GROUP TEXT	100.0	0.000	0.000	0.000	9.524	0.000	4.762	0.000	4.762	0.000	4.762	71.429	0.000	0.000
GROUP FOOT	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.091	0.000	0.000	90.909
COLUMN TOTAL	100.0	10.606	4.167	6.818	6.439	7.576	6.061	8.712	3.409	5.682	11.364	7.576	4.924	11.742

PREDICTED GROUPS

1973

GROUP	BLOG	MEYL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	HOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLOG	100.0	48.000	0.000	4.000	12.000	0.000	12.000	8.000	8.000	8.000	0.000	0.000	0.000	0.000
GROUP MEYL	100.0	0.000	33.333	6.667	13.333	20.000	0.000	0.000	6.667	13.333	0.000	0.000	0.000	0.000
GROUP FOOD	100.0	0.000	0.000	71.429	4.762	0.000	4.762	0.000	4.762	4.762	0.000	9.524	9.524	4.762
GROUP PACK	100.0	8.646	0.000	4.348	6.000	4.217	4.348	0.000	4.348	0.636	0.000	0.000	0.000	0.000
GROUP CHEM	100.0	4.167	0.000	4.167	54.167	4.167	0.000	0.000	4.167	0.000	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	0.000	0.000	0.000	0.000	0.000	6.000	16.000	5.263	13.043	0.000	5.263	0.000	0.000
GROUP INPL	100.0	10.526	0.000	0.263	0.000	0.000	0.000	16.000	0.000	0.000	0.000	5.000	0.000	0.000
GROUP MACH	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GROUP LIEL	100.0	6.667	0.000	6.667	6.667	0.000	0.000	0.000	66.667	0.000	0.000	0.000	0.000	0.000
GROUP HOCO	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GROUP CLTH	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GROUP WOOL	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GROUP TEXT	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GROUP FOOT	100.0	18.182	0.000	9.091	0.000	4.762	0.000	0.000	0.000	0.000	9.524	14.286	57.143	4.762
COLUMN TOTAL	100.0	7.576	1.894	7.355	12.121	7.197	7.197	8.333	6.061	6.439	9.091	8.712	7.576	6.061

SUMMARY TABLES PROBABILITY DISTRIBUTION FOR QUADRATIC CLASSIFICATION

PREDICTED GROUPS

1974

GROUP	BLOG	MEYL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	HOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLOG	100.0	48.000	0.000	4.000	8.000	0.000	8.000	4.000	0.000	12.000	4.000	0.000	4.000	0.000
GROUP MEYL	100.0	0.000	33.333	6.667	6.667	13.333	0.000	0.000	0.000	0.667	0.000	0.000	0.000	0.000
GROUP FOOD	100.0	0.000	0.000	76.190	4.762	0.000	0.000	0.000	0.000	0.000	0.000	4.762	4.762	0.000
GROUP PACK	100.0	4.348	0.000	0.000	73.913	0.000	0.000	8.696	0.000	4.348	0.000	0.000	4.348	0.000
GROUP CHEM	100.0	4.167	0.000	8.333	12.500	66.667	4.167	0.000	0.000	0.000	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	4.762	4.762	0.000	0.000	0.000	52.381	4.762	4.762	9.524	4.762	0.000	3.524	0.000
GROUP INPL	100.0	0.000	0.000	0.000	5.263	5.263	15.789	68.421	0.000	0.000	0.000	0.000	0.000	0.000
GROUP MACH	100.0	0.000	7.692	0.000	0.000	0.000	7.692	0.000	69.231	0.000	0.000	0.000	0.000	0.000
GROUP LIEL	100.0	6.667	6.667	0.000	0.000	0.000	6.667	13.333	6.667	46.667	0.000	0.000	6.667	0.000
GROUP HOCO	100.0	0.000	0.000	0.000	5.882	0.000	11.765	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GROUP CLTH	100.0	0.000	0.000	0.000	0.000	0.000	0.000	4.000	4.000	0.000	0.000	0.000	0.000	0.000
GROUP WOOL	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GROUP TEXT	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
GROUP FOOT	100.0	9.091	0.000	9.091	9.091	4.762	0.000	0.000	0.000	0.000	18.182	0.000	9.091	45.455
COLUMN TOTAL	100.0	6.439	4.545	9.091	11.364	9.091	7.955	8.712	4.545	3.409	8.712	5.303	9.474	2.652

SUMMARY TABLES PROBABILITY DISTRIBUTION FOR QUADRATIC CLASSIFICATION

Appendix 8.2 (contd)

PERCENT TABLE OF TOTAL QUADRATIC CLASSIFICATION

Original Sample Method

COLUMNS CORRESPOND TO PREDICTED GROUP MEMBERSHIP
ROWS CORRESPOND TO ACTUAL INPUTED GROUP MEMBERSHIP
VALUES ARE PERCENT OF TOTAL IN CLASS

1975

PREDICTED GROUPS

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	52.000	0.000	0.000	12.000	12.000	0.000	0.000	0.000	0.000	12.000	0.000	0.000	13.333	0.000
GROUP METL	100.0	0.000	46.667	0.000	13.333	6.667	0.000	0.000	0.000	0.000	0.000	4.762	4.762	0.000	0.000
GROUP FOOD	100.0	4.762	4.762	80.952	0.000	0.000	0.000	0.000	0.000	0.000	0.000	4.762	4.762	4.348	0.000
GROUP PACK	100.0	13.043	4.348	4.348	30.435	0.000	4.348	4.348	0.000	4.348	21.739	4.348	0.000	4.348	0.000
GROUP CHEM	100.0	12.500	8.333	4.167	0.000	62.500	0.000	0.000	4.167	0.000	0.000	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	4.762	9.524	0.000	0.000	0.000	61.365	0.000	4.762	0.000	19.048	0.000	0.000	0.000	0.000
GROUP INPL	100.0	0.000	10.526	0.000	0.000	5.263	5.263	57.895	0.000	5.263	5.263	10.526	0.000	7.692	0.000
GROUP MACH	100.0	7.692	7.692	0.000	0.000	0.000	7.692	61.538	7.692	0.000	0.000	0.000	0.000	0.000	0.000
GROUP LIEL	100.0	6.667	0.000	0.000	13.333	0.000	6.667	13.333	46.667	6.667	6.667	0.000	0.000	0.000	0.000
GROUP MOCO	100.0	0.000	0.000	5.882	0.000	0.000	5.882	11.765	0.000	0.000	64.706	0.000	5.882	0.000	0.000
GROUP CLTH	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	17.000	17.000	8.000	0.000
GROUP WOOL	100.0	0.000	7.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	7.143	78.571	7.143	0.000
GROUP TEXT	100.0	9.524	0.000	4.762	14.286	0.000	4.762	4.762	0.000	0.000	9.524	4.762	9.524	38.095	0.000
GROUP FOOT	100.0	18.182	0.000	9.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	18.182	18.182	0.000	36.364
COLUMN TOTAL	100.0	10.227	6.439	8.333	6.818	7.576	7.197	7.197	5.303	3.788	11.364	5.848	7.576	6.439	1.894

SUMMARY TABLES PROBABILITY DISTRIBUTION FOR QUADRATIC CLASSIFICATION

PREDICTED GROUPS

1976

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	52.000	0.000	0.000	8.000	4.000	0.000	0.000	0.000	0.000	12.000	0.000	0.000	4.000	0.000
GROUP METL	100.0	0.000	46.667	0.000	13.333	13.333	0.000	6.667	0.000	0.000	13.333	6.667	0.000	0.000	0.000
GROUP FOOD	100.0	4.762	0.000	76.190	4.762	4.762	0.000	0.000	0.000	0.000	0.000	4.762	0.000	0.000	0.000
GROUP PACK	100.0	6.696	4.348	4.348	65.217	4.348	1.000	0.000	0.000	0.000	13.043	0.000	0.000	0.000	0.000
GROUP CHEM	100.0	16.667	12.500	0.000	8.333	50.000	0.000	0.000	0.000	0.000	4.167	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	0.000	4.762	0.000	0.000	9.524	52.381	4.762	4.762	9.524	14.286	0.000	0.000	0.000	0.000
GROUP INPL	100.0	10.526	0.000	0.000	5.263	0.000	0.000	47.368	10.526	0.000	0.000	10.526	0.000	5.263	0.000
GROUP MACH	100.0	1.000	0.000	0.000	0.000	0.000	0.000	7.692	61.538	7.692	15.385	0.000	0.000	7.692	0.000
GROUP LIEL	100.0	0.000	0.000	0.000	6.667	0.000	0.000	0.000	13.333	80.000	0.000	0.000	0.000	0.000	0.000
GROUP MOCO	100.0	0.000	5.882	0.000	5.882	0.000	0.000	0.000	0.000	5.882	70.471	0.000	1.000	0.000	0.000
GROUP CLTH	100.0	0.000	0.000	0.000	4.000	0.000	0.000	12.000	0.000	0.000	0.000	76.000	4.000	0.000	0.000
GROUP WOOL	100.0	0.000	0.000	7.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	71.429	7.143	7.143	0.000
GROUP TEXT	100.0	14.286	0.000	3.524	4.762	0.000	0.000	4.762	4.762	9.524	0.000	9.524	0.000	42.857	0.000
GROUP FOOT	100.0	9.091	0.000	9.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	81.818
COLUMN TOTAL	100.0	9.848	5.682	7.955	10.227	7.955	4.924	6.061	6.061	6.818	11.364	9.470	4.167	5.682	3.788

SUMMARY TABLES PROBABILITY DISTRIBUTION FOR QUADRATIC CLASSIFICATION

PREDICTED GROUPS

1977

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	75.000	4.167	0.000	8.333	0.000	0.000	0.000	4.167	0.000	0.000	0.000	0.000	8.333	0.000
GROUP METL	100.0	0.000	53.846	0.000	7.692	15.385	7.692	0.000	0.000	0.000	7.692	0.000	0.000	7.692	0.000
GROUP FOOD	100.0	0.000	0.000	79.000	5.000	0.000	0.000	0.000	0.000	0.000	0.000	5.000	0.000	0.000	10.000
GROUP PACK	100.0	9.524	0.000	4.762	66.667	0.000	0.000	0.000	0.000	0.000	19.048	0.000	0.000	0.000	0.000
GROUP CHEM	100.0	12.500	4.167	8.333	4.167	62.500	4.167	0.000	0.000	0.000	0.000	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	5.556	0.000	5.556	5.556	0.000	11.111	16.667	5.556	0.000	0.000	0.000	0.000	0.000	0.000
GROUP INPL	100.0	0.000	0.000	0.000	0.000	0.000	5.556	22.222	0.000	0.000	0.000	0.000	5.556	11.111	0.000
GROUP MACH	100.0	21.429	0.000	0.000	0.000	0.000	7.143	0.000	57.143	0.000	7.143	0.000	7.143	0.000	0.000
GROUP LIEL	100.0	0.000	0.000	0.000	0.000	0.000	21.429	21.429	0.000	62.857	14.286	0.000	0.000	14.286	0.000
GROUP MOCO	100.0	0.000	0.000	0.000	6.250	0.000	6.250	5.250	0.000	0.000	81.250	0.000	0.000	0.000	0.000
GROUP CLTH	100.0	0.000	0.000	0.000	0.000	4.167	0.000	4.167	0.000	0.000	0.000	79.167	4.167	4.167	0.000
GROUP WOOL	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14.286	85.714	0.000	0.000
GROUP TEXT	100.0	0.000	0.000	0.000	5.000	10.000	0.000	5.000	5.000	0.000	0.000	10.000	5.000	60.000	0.000
GROUP FOOT	100.0	0.000	0.000	18.182	0.000	9.091	0.000	0.000	0.000	0.000	0.000	9.091	9.091	0.000	54.545
COLUMN TOTAL	100.0	10.757	3.486	7.958	8.765	8.367	7.570	8.367	4.382	2.490	9.163	10.359	7.171	7.968	3.167

COLUMNS CORRESPOND TO PREDICTED GROUP MEMBERSHIP
 ROWS CORRESPOND TO ACTUAL INPUTED GROUP MEMBERSHIP
 VALUES ARE PERCENT OF TOTAL IN CLASS

Lachenbruch Holdout (LH) Method

PREDICTED GROUPS

1972

	TOTAL	BLDG	MFTL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	36.000	4.000	8.000	8.000	24.000	0.000	8.000	4.000	0.000	8.000	0.000	0.000	0.000	0.000
GROUP MFTL	100.0	13.333	6.667	13.333	6.667	6.667	0.000	13.333	6.667	6.667	13.333	0.000	0.000	13.333	0.000
GROUP FOOD	100.0	0.000	4.762	42.857	4.762	0.000	0.000	4.762	0.000	4.762	4.762	4.762	9.524	9.524	9.524
GROUP PACK	100.0	13.043	4.348	8.696	13.043	13.043	0.000	8.696	0.000	4.348	17.391	4.348	0.000	8.696	4.348
GROUP CHEM	100.0	29.167	4.167	0.000	12.500	25.000	12.500	4.167	0.000	0.000	8.333	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	0.000	4.762	0.000	14.286	9.524	19.048	14.286	0.000	14.286	14.286	9.524	0.000	0.000	0.000
GROUP INPL	100.0	10.526	0.000	10.526	0.000	0.000	10.526	42.105	5.263	10.526	0.000	0.000	5.263	5.263	0.000
GROUP MACH	100.0	0.000	23.077	0.000	0.000	0.000	15.385	15.385	15.385	7.692	7.692	7.692	7.692	0.000	0.000
GROUP LIEL	100.0	6.667	0.000	6.667	6.667	20.000	13.333	6.667	0.000	40.000	0.000	0.000	0.000	0.000	0.000
GROUP MOCO	100.0	23.529	0.000	0.000	5.882	5.882	5.882	0.000	0.000	0.000	47.059	0.000	0.000	11.765	0.000
GROUP CLTH	100.0	4.000	4.000	4.000	0.000	8.000	4.000	0.000	0.000	4.000	4.000	32.000	8.000	20.000	8.000
GROUP WOOL	100.0	14.286	0.000	7.143	7.143	0.000	7.143	0.000	0.000	0.000	0.000	35.714	7.143	21.429	0.000
GROUP TEXT	100.0	4.762	0.000	0.000	9.524	0.000	0.000	4.762	0.000	4.762	0.000	14.286	14.286	47.619	0.000
GROUP FOOT	100.0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	9.091	9.091	0.000	36.364	0.000	27.273	18.182
COLUMN TOTAL	100.0	12.121	3.798	7.576	6.818	9.091	6.061	8.712	2.273	6.818	9.091	9.848	3.788	11.364	2.652

PREDICTED GROUPS

1973

	TOTAL	BLDG	MFTL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	28.000	4.000	4.000	16.000	4.000	8.000	12.000	8.000	8.000	8.000	0.000	0.000	0.000	0.000
GROUP MFTL	100.0	0.000	6.667	13.333	13.333	26.667	5.667	6.667	6.667	6.667	13.333	0.000	0.000	0.000	0.000
GROUP FOOD	100.0	0.000	4.762	52.381	4.762	9.524	0.000	4.762	0.000	0.000	0.000	0.000	4.762	14.286	4.762
GROUP PACK	100.0	13.043	4.348	4.348	34.783	8.696	0.000	17.391	0.000	4.348	8.696	0.000	0.000	4.348	0.000
GROUP CHEM	100.0	8.333	0.000	4.167	29.167	37.500	4.167	0.000	0.000	4.167	0.000	8.333	4.167	0.000	0.000
GROUP ELEC	100.0	4.762	9.524	0.000	4.762	9.524	23.810	14.286	0.000	9.524	19.048	4.762	0.000	0.000	0.000
GROUP INPL	100.0	31.579	0.000	0.000	5.263	0.000	10.526	21.053	21.053	5.263	0.000	0.000	5.263	0.000	0.000
GROUP MACH	100.0	7.692	7.692	0.000	0.000	0.000	7.692	30.769	7.692	0.000	7.692	7.692	0.000	23.077	0.000
GROUP LIEL	100.0	13.333	0.000	0.000	6.667	0.000	26.667	13.333	20.000	6.667	0.000	6.667	0.000	6.667	0.000
GROUP MOCO	100.0	0.000	0.000	11.765	11.765	0.000	11.765	0.000	17.647	0.000	41.176	0.000	0.000	5.882	0.000
GROUP CLTH	100.0	0.000	8.000	0.000	4.000	4.000	4.000	0.000	0.000	0.000	8.000	52.000	12.000	4.000	4.000
GROUP WOOL	100.0	0.000	0.000	7.143	7.143	7.143	0.000	0.000	0.000	0.000	0.000	14.286	28.571	14.286	21.429
GROUP TEXT	100.0	0.000	9.524	0.000	4.762	9.524	4.762	0.000	4.762	0.000	0.000	14.286	14.286	33.333	4.762
GROUP FOOT	100.0	18.182	0.000	18.182	0.000	0.000	0.000	0.000	0.000	0.000	0.000	27.273	18.182	0.000	18.182
COLUMN TOTAL	100.0	9.091	4.167	7.955	11.364	9.091	7.576	8.333	5.682	3.409	7.576	9.848	5.682	7.197	3.030

PREDICTED GROUPS

1974

	TOTAL	BLDG	MFTL	FOOD	PACK	CHEM	ELEC	INPL	MACH	LIEL	MOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	24.000	0.000	0.000	20.000	12.000	12.000	8.000	0.000	4.000	12.000	4.000	0.000	4.000	0.000
GROUP MFTL	100.0	0.000	13.333	13.333	13.333	13.333	13.333	6.667	6.667	0.000	6.667	0.000	0.000	13.333	0.000
GROUP FOOD	100.0	0.000	4.762	52.381	4.762	14.286	0.000	0.000	0.000	4.762	0.000	0.000	9.524	4.762	4.762
GROUP PACK	100.0	13.043	8.696	0.000	30.435	4.348	4.348	8.696	0.000	8.696	13.043	4.348	0.000	4.348	0.000
GROUP CHEM	100.0	16.667	4.167	12.500	20.833	29.167	4.167	0.000	4.167	4.167	0.000	4.167	0.000	0.000	0.000
GROUP ELEC	100.0	4.762	4.762	0.000	0.000	14.286	28.571	14.286	4.762	9.524	4.762	0.000	0.000	14.286	0.000
GROUP INPL	100.0	10.526	5.263	0.000	10.526	5.263	36.842	26.316	0.000	0.000	5.263	0.000	0.000	0.000	0.000
GROUP MACH	100.0	23.077	15.385	0.000	0.000	0.000	7.692	0.000	23.077	0.000	15.385	15.385	0.000	3.000	0.000
GROUP LIEL	100.0	13.333	6.667	0.000	0.000	13.333	6.667	13.333	13.333	20.000	0.000	0.000	0.000	6.667	6.667
GROUP MOCO	100.0	5.882	0.000	5.882	11.765	0.000	11.765	11.765	5.882	5.882	35.294	0.000	5.882	0.000	0.000
GROUP CLTH	100.0	0.000	0.000	0.000	4.000	8.000	4.000	4.000	8.000	0.000	0.000	40.000	8.000	24.000	0.000
GROUP WOOL	100.0	0.000	0.000	14.286	7.143	14.286	0.000	7.143	0.000	0.000	0.000	7.143	28.571	7.143	14.286
GROUP TEXT	100.0	0.000	0.000	9.524	9.524	4.762	0.000	4.762	0.000	0.000	0.000	23.810	14.286	28.571	4.762
GROUP FOOT	100.0	9.091	0.000	9.091	9.091	0.000	0.000	0.000	0.000	9.091	0.000	27.273	9.091	18.182	9.091
COLUMN TOTAL	100.0	8.712	4.167	8.333	10.985	10.227	9.470	7.576	4.167	4.545	6.439	9.091	4.924	9.091	2.273

COLUMNS CORRESPOND TO PREDICTED GROUP MEMBERSHIP
 ROWS CORRESPOND TO ACTUAL INPUTED GROUP MEMBERSHIP
 VALUES ARE PERCENT OF TOTAL IN CLASS

Appendix 8.2 (contd)

Lachenbruch Holdout Method

PREDICTED GROUPS

1975

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	HACH	LIEL	HOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	20.000	0.000	4.000	28.000	20.000	0.000	8.000	0.000	4.000	12.000	0.000	0.000	4.000	0.000
GROUP METL	100.0	6.667	13.333	6.667	13.333	6.667	6.667	6.667	6.667	0.000	13.333	0.000	0.000	20.000	0.000
GROUP FOOD	100.0	4.762	14.286	57.143	0.000	9.524	3.000	0.000	0.000	0.000	0.000	9.524	4.762	0.000	0.000
GROUP PACK	100.0	21.739	4.348	4.348	17.391	0.000	4.348	4.348	0.000	4.348	21.739	4.348	0.000	4.348	8.696
GROUP CHEM	100.0	16.667	16.667	8.333	4.167	33.333	0.000	0.000	4.167	4.167	0.000	4.167	0.000	4.167	4.167
GROUP ELEC	100.0	14.286	9.524	0.000	0.000	0.000	14.286	9.524	9.524	9.524	23.810	0.000	0.000	4.762	4.762
GROUP INPL	100.0	10.526	10.526	0.000	0.000	10.526	10.526	5.263	21.053	5.263	10.526	15.789	0.000	0.000	0.000
GROUP HACH	100.0	15.385	7.692	0.000	0.000	7.692	0.000	15.385	15.385	15.385	0.000	0.000	0.000	15.385	7.692
GROUP LIEL	100.0	6.667	0.000	6.667	20.000	6.667	6.667	20.000	13.333	13.333	6.667	0.000	0.000	0.000	0.000
GROUP HOCO	100.0	11.765	9.000	5.882	17.647	0.000	17.647	11.765	0.000	0.000	23.529	0.000	5.882	0.000	5.882
GROUP CLTH	100.0	0.000	0.000	0.000	0.000	0.000	4.000	0.000	8.000	0.000	4.000	48.000	12.000	8.000	16.000
GROUP WOOL	100.0	0.000	7.143	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	35.714	21.429	28.571	7.143
GROUP TEXT	100.0	14.286	0.000	9.524	19.048	4.762	4.762	4.762	0.000	0.000	9.524	14.286	14.286	4.762	0.000
GROUP FOOT	100.0	18.182	0.000	9.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	45.455	27.273	0.000	0.000
COLUMN TOTAL	100.0	11.742	6.061	8.333	9.091	7.955	4.924	5.682	5.303	3.788	9.470	12.121	5.303	6.061	4.167

PREDICTED GROUPS

1976

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	HACH	LIEL	HOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	28.000	8.000	0.000	24.000	4.000	8.000	0.000	4.000	0.000	16.000	0.000	0.000	4.000	4.000
GROUP METL	100.0	6.667	0.000	13.333	20.000	20.000	0.000	13.333	0.000	0.000	13.333	6.667	0.000	6.667	0.000
GROUP FOOD	100.0	9.524	4.762	47.619	9.524	4.762	0.000	9.524	0.000	0.000	4.762	0.000	4.762	4.762	0.000
GROUP PACK	100.0	34.783	13.043	4.348	17.391	4.348	4.348	0.000	4.348	0.000	13.043	0.000	4.348	0.000	0.000
GROUP CHEM	100.0	16.667	12.500	4.167	8.333	33.333	4.167	4.167	4.167	0.000	4.167	4.167	0.000	4.167	0.000
GROUP ELEC	100.0	0.000	9.524	0.000	0.000	19.048	9.524	14.286	4.762	19.048	14.286	9.524	0.000	9.524	0.000
GROUP INPL	100.0	15.789	10.526	0.000	5.263	0.000	10.526	10.526	5.263	10.526	10.526	10.526	0.000	10.526	0.000
GROUP HACH	100.0	7.692	0.000	0.000	0.000	0.000	0.000	15.385	15.385	15.385	15.385	0.000	15.385	15.385	0.000
GROUP LIEL	100.0	0.000	6.667	0.000	13.333	6.667	6.667	0.000	26.667	20.000	6.667	6.667	0.000	6.667	0.000
GROUP HOCO	100.0	0.000	17.647	0.000	11.765	5.882	0.000	11.765	0.000	11.765	35.294	0.000	0.000	5.882	0.000
GROUP CLTH	100.0	0.000	0.000	0.000	4.000	0.000	4.000	16.000	0.000	3.000	3.000	48.000	12.000	12.000	4.000
GROUP WOOL	100.0	0.000	0.000	7.143	0.000	0.000	0.000	0.000	7.143	0.000	0.000	21.429	35.714	14.286	14.286
GROUP TEXT	100.0	14.286	0.000	14.286	4.762	4.762	4.762	4.762	4.762	9.524	0.000	14.286	0.000	19.048	4.762
GROUP FOOT	100.0	9.091	0.000	18.182	0.000	0.000	0.000	0.000	0.000	0.000	0.000	36.364	27.273	0.000	9.091
COLUMN TOTAL	100.0	11.364	6.439	7.576	9.091	7.955	4.167	7.197	5.303	5.303	9.470	10.227	5.682	7.955	2.273

SUMMARY TABLES PROBABILITY DISTRIBUTION FOR QUADRATIC CLASSIFICATION

PREDICTED GROUPS

1977

	TOTAL	BLDG	METL	FOOD	PACK	CHEM	ELEC	INPL	HACH	LIEL	HOCO	CLTH	WOOL	TEXT	FOOT
GROUP BLDG	100.0	25.000	4.167	0.000	16.667	16.667	4.167	8.333	8.333	4.167	0.000	4.167	0.000	8.333	0.000
GROUP METL	100.0	0.000	7.692	7.692	15.385	38.462	7.692	7.692	0.000	0.000	7.692	0.000	0.000	7.692	0.000
GROUP FOOD	100.0	0.000	20.000	30.000	15.000	5.000	0.000	5.000	0.000	0.000	0.000	5.000	5.000	0.000	15.000
GROUP PACK	100.0	23.810	9.524	9.524	19.048	0.000	4.762	0.000	4.762	4.762	19.048	4.762	0.000	0.000	0.000
GROUP CHEM	100.0	12.500	8.333	8.333	8.333	29.167	12.500	4.167	0.000	0.000	0.000	8.333	0.000	4.167	4.167
GROUP ELEC	100.0	11.111	0.000	5.556	5.556	5.556	16.667	16.667	11.111	11.111	5.556	5.556	0.000	5.556	0.000
GROUP INPL	100.0	16.667	0.000	0.000	5.556	0.000	11.111	16.667	16.667	0.000	11.111	5.556	5.556	11.111	0.000
GROUP HACH	100.0	35.714	0.000	0.000	0.000	7.143	7.143	0.000	7.143	21.429	7.143	0.000	7.143	7.143	0.000
GROUP LIEL	100.0	7.143	0.000	0.000	0.000	0.000	21.429	14.286	7.143	0.000	14.286	0.000	0.000	35.714	0.000
GROUP HOCO	100.0	0.000	0.000	0.000	12.500	0.000	18.750	12.500	12.500	5.208	17.500	0.000	0.000	0.000	0.000
GROUP CLTH	100.0	0.000	0.000	4.167	0.000	8.333	4.167	4.167	4.167	4.167	4.167	37.500	8.333	16.667	4.167
GROUP WOOL	100.0	0.000	0.000	7.143	0.000	14.286	7.143	0.000	0.000	0.000	0.000	28.571	28.571	7.143	7.143
GROUP TEXT	100.0	5.000	0.000	5.000	5.000	15.000	0.000	15.000	5.000	5.000	0.000	20.000	10.000	15.000	0.000
GROUP FOOT	100.0	0.000	0.000	18.182	0.000	9.091	0.000	0.000	0.000	0.000	0.000	45.455	18.182	0.000	0.000
COLUMN TOTAL	100.0	10.359	3.984	6.773	7.968	10.757	7.968	7.570	5.578	4.382	7.171	11.554	5.179	8.367	2.390

Appendix 8.3

Means of 14 Manufacturing Industries on Discriminant Ratios

Industry	Days Drs	Dr/CA	Log Dr/INV	Sqrt VA/ATCE	Sqrt ER/TA	Sqrt FF/S	Log CF/S	Sqrt Cr/CL	Dr/Cr	Log S/AFA
BLDG	77.83	.52	.53	.86	.52	.62	-.58	.59	1.30	1.42
METL	77.64	.50	.16	.74	.44	.60	-.60	.59	1.28	1.72
FOOD	46.81	.48	.11	.82	.48	.58	-.62	.50	1.17	1.66
PACK	72.75	.48	.23	.83	.53	.60	-.54	.63	1.28	1.25
CHEM	81.39	.48	.35	.71	.41	.61	-.54	.56	1.24	1.41
ELEC	90.66	.42	.01	.89	.57	.62	-.57	.57	1.27	1.57
INPL	90.84	.45	.17	.90	.59	.59	-.60	.63	1.18	1.87
MACH	91.22	.39	-.29	.77	.55	.60	-.57	.50	1.44	1.60
LIEL	83.72	.46	.10	.92	.52	.65	-.55	.55	1.23	1.74
MOCO	76.74	.46	-.03	.87	.59	.60	-.59	.64	1.18	1.47
GLTH	51.65	.33	-.46	.95	.63	.60	-.60	.51	1.18	1.77
WOOL	54.88	.31	-.59	.76	.53	.59	-.59	.42	1.26	1.59
TEXT	59.37	.39	-.32	.83	.55	.59	-.59	.54	1.21	1.61
FOOT	35.97	.32	-.67	1.01	.63	.58	-.63	.48	1.08	1.87
univariate										
F-ratio	15.83	7.99	12.38	4.34	6.22	2.97	4.89	4.10	2.18	2.26
df=13,250										

Note : $F_{0.01} \approx 2.25$ and $F_{0.05} \approx 1.80$. Data relate to the year when the ratio first appeared in a model. Some discriminant ratios e.g. EBIT/S are not listed since ratios representing the same dimension as they do are already included. df = degrees of freedom.

See Yeomans (1976) for F tables.

Appendix 9.1

Classification Matrices for 3 Super-industries Analysis (Prediction Samples)

(Only correct classification rates in percent shown)

Predicted Year	Group	Base Year					
		1972		1973		1974	
		Q	L	Q	L	Q	L
1973	PRCS	65	67				
	ENGG	86	80				
	TEXT	78	82				
1974	PRCS	54	58	63	64		
	ENGG	85	85	79	81		
	TEXT	82	80	77	79		
1975	PRCS	63	69	68	65	72	69
	ENGG	84	84	80	79	78	78
	TEXT	75	73	66	65	73	73
1976	PRCS	58	63	64	67	70	73
	ENGG	80	79	69	69	68	67
	TEXT	78	75	73	70	69	70
1977	PRCS	60	66	70	70	71	73
	ENGG	84	83	76	70	73	73
	TEXT	74	73	68	68	72	74

Note: Base year is the year of the model used in prediction.

Q = Quadratic rule; L = Linear rule. See paragraph 9.3.3

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