EXPERT SYSTEMS FOR VENDOR SELECTION

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THESIS SUMMARY

The survival of organisations, especially SMEs, depends, to the greatest extent, on those who supply them with the required material input. This is because if the supplier fails to deliver the right materials at the right time and place, and at the right price, then the recipient organisation is bound to fail in its obligations to satisfy the needs of its customers, and to stay in business. Hence, the task of choosing a supplier(s) from a list of vendors, that an organisation will trust with its very existence, is not an easy one.

This project investigated how purchasing personnel in organisations solve the problem of vendor selection. The investigation went further to ascertain whether an Expert Systems model could be developed and used as a plausible solution to the problem. An extensive literature review indicated that very scanty research has been conducted in the area of Expert Systems for Vendor Selection, whereas many research theories in expert systems and in purchasing and supply management chain, respectively, had been reported. A survey questionnaire was designed and circulated to people in the industries who actually perform the vendor selection tasks. Analysis of the collected data confirmed the various factors which are considered during the selection process, and established the order in which those factors are ranked.

Five of the factors, namely, Production Methods Used, Vendors Financial Background, Manufacturing Capacity, Size of Vendor Organisations, and Suppliers Position in the Industry; appeared to have similar patterns in the way organisations ranked them. These patterns suggested that the bigger the organisation, the more importantly they regarded the above factors. Further investigations revealed that respondents agreed that the most important factors were: Product Quality, Product Price and Delivery Date.

The most apparent pattern was observed for the Vendors Financial Background. This generated curiosity which led to the design and development of a prototype expert system for assessing the financial profile of a potential supplier(s). This prototype was called ESfVS. It determines whether a prospective supplier(s) has good financial background or not. ESfVS was tested by the potential users who then confirmed that expert systems have great prospects and commercial viability in the domain for solving vendor selection problems.

Keywords: Vendor Selection, Expert Vendor Rating, Financial Assessor, Expert Systems, Financial Ratios.

DEDICATION PAGE

This thesis is dedicated to those who gave me life and took good care of me throughout the infant and teenage periods of my life, and who passed away during my many years of absence from home. These are my:

Father, Chief Stephen E. Obidigbo,

Mother, Mrs. Rose A Obidigbo,

Brother, Engr. Eric P. Obidigbo and

Sister, Mrs. Caroline Agha (nee Obidigbo).

Apart from the members of the Obidigbo family, other people who were my inspirations, as a teenager, in so many different ways; included M-M Plaza (Clement Obagha), late Jimmy Asaraja (Raymond Nweke) and Professor IG Okafor _ about whom I heard of the word 'President' for the first time.

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Glossary of Terms Used

A I : Artificial Intelligence

Attribute: The content of an entity. Eg, if the entity were a person then the attribute could be Name, Age, Sex, etc.

Domain: The subject area which is included within the scope of expert systems.

Entity: Event, or knowledge, or person, etc. ie. something about which data can be collected and stored, just like a record, e.g. personnel record is a group of data about a person, and the person is the entity of the record.

E. S.: Expert Systems.

Source: A firm, an individual, or a place which provides goods and / or services.

Supplier: The firm, person (or persons) who has the mandate to supply goods and / or services to another.

Vendor: The firm, person (or persons) who provides goods and / or services for sale but have not been contracted by another to supply. Once given the mandate, the vendor becomes the supplier.

1. INTRODUCTION

Choosing one or a few suppliers from a list of many vendors poses great problems for those who are responsible for the selection and evaluation of potential suppliers. The suppliers are outside organisations who provide the materials required by other organisations. These materials can be in the form of raw materials, component parts, etc. which constitute the material input for an organisation. They are used by the recipient organisations to manufacture their own products in order to satisfy the needs of their customers.

To select one or a few suppliers from a whole world of vendors out there could require a great deal of efforts. The chosen supplier(s) would be responsible for ensuring the availability of the materials which the recipient organisation(s) require for their existence and survival. This implies entrusting the existence and survival of an organisation to an outsider (i.e. the supplier). The scope of this problem is discussed in detail in chapter two.

Chapter two defines the research problems and provides a full explanation of the research programme objective as well as the motivation for conducting the research project.

The aim of this research project is to look at various ways in which the problem of vendor selection is tackled, and to assess whether Expert Systems technology can be used to help solve the problem, and if so, how?.

The work for this thesis is organised into three sections, namely:

- Data Collection,
- Development Phase and
- Test Domain.

DATA COLLECTION:

The first part of the research programme involved making contact with people in industry who actually performed the task of selecting the supplier(s). The purpose of the initial contact was to establish whether what the researcher believed to be a problem was indeed perceived as such by those who are in the business. The detailed discussion is presented in chapter two.

Chapter three is the review of the relevant literature. It discusses the process of vendor selection in various ways, the definition of expert systems and its applications and benefits. It goes further to discuss the issues surrounding the use of expert systems in organisations. The chapter also highlights the extent to which work had been carried out in the area of using expert systems technologies for selection processes in general and in purchasing and supply in particular.

Chapter four examines the methods and methodologies used during the research process. These included those used for data collection, data analysis, program developments, and the prototype testing.

Chapter five introduced the use of questionnaire to capture knowledge about:

- how the problem(s) of vendor selection is actually tackled in various organisations, for example, the factors which are taken into consideration in the process of selection as well as the degree of importance of these factors,
- whether some form of commonality existed in the way that organisations solve the problem(s),
- the level of awareness of expert system technologies by those responsible for choosing suppliers and,
- the degree of willingness to use an expert systems technology in solving the problem.

Contacts with purchasing professionals and literature survey established twenty factors that are considered during the vendor selection process. An attempt was therefore made to use these factors to develop an Expert Systems Program which those in the purchasing organisations could use for the selection and evaluation of potential supplier(s). This effort confronted the problems of resource limitations and time constraints. For this reason, a prototype Expert Systems program which addressed one of the twenty factors (i.e. Vendors' Financial Background) was developed. The program is called ESfVS. It was intended to demonstrate that expert system capabilities can be used to help solve problems in this application domain.

Chapter six discusses the acquired knowledge and their interpretations which were used to build the knowledge base. It revealed what constituted a good financial background of a company, and the criteria for determining whether a company's financial background is good or not (for this purpose) was established

DEVELOPMENT PHASE:

The later part of the research project focused on the design and development process of the prototype system. Chapter seven examines the design and development process of the ESfVS. It includes the systems design concepts, justification of the systems development tools used and how the rules in the knowledge base were formulated.

TEST DOMAIN:

Chapter eight discusses the process of the trial tests of the prototype, and presents the achieved results. The final chapter (ie. Chapter nine) is the concluding remarks for the thesis.

2. THE RESEARCH PROBLEM DEFINITION

Usually, medium and large sized manufacturing organisations have their own purchasing departments. In many cases, Small and Medium Enterprises (SMEs) too have purchasing departments. In some other cases the SMEs can integrate the purchasing function into a broader department such as production or operations or any other, depending on the structure of the organisation, Lockyer et al [1988]. Although the roles of a purchasing department may differ from one company to another, Baily and Farmer [1981] agreed that there are specific activities which are common to them.

Organisations need a steady supply of input materials from suppliers. If, for instance, the supplier fails to deliver the required input materials (for whatever reason) as agreed to the organisation, then the recipient organisation will not be able to produce and provide the needed products to satisfy its customers. Organisations do not normally operate in a vacuum. The suppliers themselves depend on other suppliers or organisations for their own existence and survival, etc.

Figure 2.1 overleaf, describes the relationship between the supplier and the receiving organisation. The bold arrows represent the goods going in and out of a manufacturing organisation. They indicate that goods (ie materials) have to be going in to an organisation to enable it produce its own goods in order to satisfy its customers.

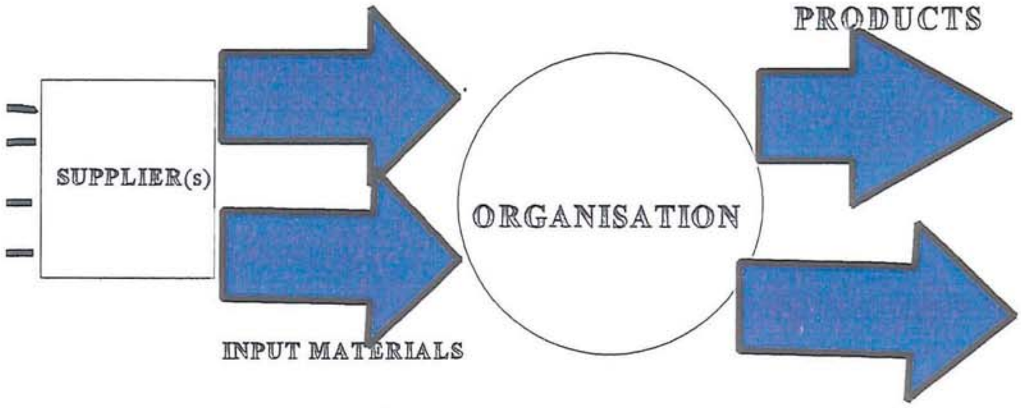

Figure 2.1 SUPPLIER AND ORGANISATION RELATIONSHIP

2.1. THE PURCHASING FUNCTION

The function of a purchasing department, according to Wild [1979] is to ensure the efficient running of the firm by providing the following:

* The required material input

This refers to the physical characteristics of the materials which the organisation needs in order to manufacture its own products. In the absence of the material input, it is unlikely that there will be an effective business process. It is the responsibility of the department therefore, to ensure that the type, the shape, the size, the colour, etc of the raw materials meet the business process requirements. It is also necessary to indicate that in certain business activity, the material inputs contribute to the full definition of the company's business process. For instance, the type of raw materials used by an organisation determines the type of the output/product of the said organisation.

*   The required quality of the materials

This relates to the ability of the purchased materials to perform the functions for which they are procured. One of the functions of the department is to make sure that, for example, no damaged or deformed or out-dated goods are procured. Whether the procurement is for capital goods or for consumables, the purchased items must meet any established quality requirement, otherwise the goods made from them would not achieve the quality target, Vollman et al [1988]. The fact therefore remains that the quality product definition or introduction can be affected by the quality of the material(s) used.

*   The needed material quantity

This deals with the exact amount of the materials needed. The units of measurement may be in litres, metres, kilograms, etc. The provision of the required quantity of materials, without any form of unaccountable depletion or reduction, is one of the primary functions of a purchasing department. With the right quantity of materials available at any given time, the organisation will not be exposed to the dangers of running out of raw material stocks.

* On-time delivery of the input materials

This ensures that the needed materials are delivered exactly when they are promised and to the place where they are required. If the raw materials needed for production are not delivered as and when due, then the organisation cannot produce and meet its obligation to its customers as promised. This type of situation usually gives rise to machines and operatives lying idle while waiting for deliveries, thus costing the organisation more than they bargained for.

* The most economic procurement

This refers to ensuring that the best value for money purchases are made. It is the responsibility of the buying department to acquire the relevant materials at the best possible price, taking into consideration all types of available discounts, offers and concessions. This is to ensure that the desired products are manufactured with optimum cost efficiency. Other complimentary services such as: after sales services, warranties, insurance cover for capital purchases, cover for goods-in-transit, etc. should be negotiated for and secured by the buyer for the benefit of his or her organisation(s) whenever there is an opportunity to do so, Compton [1982].

The functions of the purchasing department also include developing the skills and potential of the purchasing personnel, developing purchasing policies and procedures; ensuring the continuity of supply; maintaining good relationships with vendors; keeping adequate records of purchasing transactions, etc. All the above contribute immensely to the formulation of a company's corporate policy.

2.2. IDENTIFYING THE SOURCES OF SUPPLY

The vendors or suppliers are outside organisations who run their own businesses. They are usually eager to sell their products for as much as they can to make and maximise profit in order to remain in business. It is from one or some of these vendors that the manufacturer has to buy his needed raw materials. Most components or materials (if not all) in the market are supplied by more than one company. For example a tyre (which is a component of a car) has many manufacturers and suppliers, flour (which is used for making bread) has many suppliers, etc. Each manufacturer or supplier has its own brand names and labels.

Identifying suppliers can take the form of searching through directories such as the Yellow Pages, Business Pages, The Thomson Local, Company Directory, Product Directory, the Internet, or by looking at the product labels, or by asking around, etc. Hence, in the process of searching for the supplier of a product, one may have to look up tens or hundreds or even more of companies who supply that particular product or similar products. One would then imagine the number of suppliers which a buyer could approach in the process of sourcing for one single product. The task then becomes more cumbersome if the buyer is to source for a large number of products. After identifying the possible sources of supply, he would then be confronted with the critical job of selecting a source(s).

2.3. CHOOSING A SOURCE(S)

Manufacturing organisations need a steady supply of materials which they use in making their own products. To a manufacturer, the material input requirement is a critical factor to his existence and survival. He has to purchase the needed material input from somewhere in order to produce. Unless the right materials (ie the specified quality and quantity) are purchased at the right time and at the right price, and then delivered at the required time and place, manufacturing industries will either perform badly or may not exist at all.

The question that arises therefore is:

. which one(s) of these vendors will the manufacturer entrust with the huge responsibilities for supplying the required materials?

. which vendor(s) can and will deliver as promised, bearing in mind that failure to deliver as and when required could mean the end of an entire organisation?

Hence, entrusting the existence of the entire manufacturing enterprise to the hands of an outsider (ie. the vendor(s)) requires a very careful selection and evaluation strategy. As Paulden [1977:30] puts it..

> *Failure of supplies to arrive on time or in the right condition is the most commonly quoted cause of delay in meeting a promised delivery schedule. Every manufacturer is at the mercy of another. It is therefore extremely difficult for any one factory to control its own destiny absolutely. To lapse into apathy is, however, the best way to aggravate the problem [...].*

The most important aspect of the purchasing function is deciding which supplier(s) to buy from. Who can and will deliver the agreed material quantity and quality, on time and at competitive prices - exactly as promised? According to Dobler, Burt & Lee [1990:196], England said that:

> *A good supplier is one who is at all times honest and fair in his dealing with the customers, his own employees, and himself; who has adequate plant*

> *facilities, and know-how so as to be able to provide materials which meet the purchaser's specifications, in the quantities required, and at the time promised; whose financial position is sound; whose prices are reasonable both to the buyer and to himself; whose management policies are progressive; who is alert to the need for continued improvement in both his products and his manufacturing processes; and who realises that, in the last analysis, his own interests are best served when he best serves his customers.*

Unlike in a monopoly or oligopoly situation where choice is very limited or in situations where invitation for tendering process is in vogue (in which the vendor has to vet himself first in line with the tender guidelines before submitting a tender), vendor selection in an open and free market is a difficult and complex operation. Firstly, the buyer has to develop a comprehensive list of potential suppliers, and then evaluate each prospective supplier individually.

Evaluating one individual vendor is not an easy task. It takes time and requires a human expert (or experts) who has relevant knowledge and experience in this type of application. When the number of vendors to be evaluated goes into tens and hundreds, the task becomes very cumbersome. In situations where sifting is necessary so as to narrow down the number of potential suppliers, more than one evaluation has to be done on each individual vendor. It should be realised, of course, that human experts (who perform these tasks) are not easy to come by, and some efforts are required to keep them. The efforts can be in the form of salaries and wages, bonus payments, overtime payments, very good working conditions, and other forms of incentives.

The type of evaluation necessary to determine the capabilities of the vendor depends on the nature, criticality, complexity, and the monetary value of the purchases to be made. It also varies with the buyer's knowledge of the firm being considered for an order. Kennedy's [1992] work on Supplier Selection for Buying Steel Plate suggests that buyers (generally speaking) will rely on past experience with a supplier as the main basis for selection. For purchases that are critical, complex and capital intensive, additional steps are necessary. For example, visiting the plant of the prospective supplier, the reason being to assess the plant facilities in order to determine:

* the type of equipment being used
* whether the equipment has enough capacities to meet promised dates
* the production methods used
* how flexible the production methods and the equipment are
* the quality of the products they make and to compare them with

the requirements of the materials ordered

* the type of services which they offer, eg. after sales services, insurance and protection plans, etc.
* how well organised the plant and the workforce are

The overall technology of the potential supplier(s) needs to be considered and compared with the current state of technological advancement, depending on the volume and frequency of business.

Furthermore, the financial status of the vendor needs to be examined critically. For example, checking financial statements and credit rating could reveal whether a supplier is capable of performing satisfactorily. Financial stability is essential to ensure that vendors can provide:

* continuity of supply
* reliability of product quality
* sufficient working capital to settle overheads, etc., such as overtime payment (ie. if or when needed to meet promised delivery dates)

The financial records of a supplier reveal its overall performance. For example, the volumes of sales, income, profit, loss, assets, liabilities, creditors, debtors, capital sources, etc., show the level of success a company enjoys. A buyer, for instance, would not want to place an order from a supplier who would liquidate immediately afterwards, or from a supplier who would raise his prices without consultation in order to make up for losses accumulated over the previous periods.

2.4. THE RESEARCH PROGRAMME OBJECTIVE

The aim of the programme was to investigate how organisations tackle the problem of vendor selection. The study would include identifying the factors which those entrusted with the task of choosing suppliers take into consideration during the selection process. The programme would also examine the factors individually with a view to ascertaining how importantly each factor was regarded by different organisations.

The overall objective was to find out whether an expert systems program could be employed by organisations to help solve the problem of vendor selection. An Expert System is a type of computer program which is designed to solve problems the way a human expert in a domain application solves related problems. More on expert systems and their capabilities are discussed in the next chapter. The program would consider identifiable variables, just as a human expert would, in the process of making decision(s).

Initial enquiries indicated that only very scanty research work existed in the subject area. Hence, one of the aims of the study was to find out how well informed people in purchasing and supply chain management were about expert systems. Finally, the research would ascertain whether an Expert Systems approach would be acknowledged as an alternative solution to the problem of vendor selection and evaluation by those responsible for procuring materials for the manufacturing industries.

2.5. THE RESEARCH MOTIVATION

After graduating in Business and Management Studies, the author worked as a purchasing and export administrator. The duties included:-

- sourcing for suppliers,
- collecting and analysing suppliers/product information,
- negotiating contracts,
- choosing suppliers and shipping companies,
- expediting, and
- reporting to the Managing Director.

It was part of the job to visit potential suppliers in order to assess their product types and the quality of their products, their plant capacity, their processes and methods, etc. In many cases, visits to two or more suppliers were made in one day. After spending so many hours going from one plant to another, one has to go back to the office to analyse and evaluate the collected data. At the end of the analyses and evaluation, the supplier(s) who meets the established criteria is selected. This process is very cumbersome especially when there are so many suppliers to evaluate. In many cases, more than one evaluation is performed on an individual vendor.

After discussions with business associates, the author then realised that the problem is critical and universal. Hence the thought of how the situation can be helped began to manifest. Any system (ideally a computer based system) that can mimic the way human experts solve the problem, (ie. analysing, evaluating, and then recommending a suitable vendor(s)) would be welcome as an alternative solution to the problem. After some discussions with business colleagues and initial enquiries, it was discovered that only very limited research work has been conducted in the area. See chapter 3.

Hence, it would be right to assume that the successful completion of the programme would mean an extension of the frontier of knowledge. It would also prove to be a major breakthrough in the use of computer technology for the management of purchasing and supply chain.

3. LITERATURE REVIEW

This literature review looks at the documentary evidence of how various organisations deal with the problem of vendor selection. It defines expert systems within the scope of the research and analyses their capabilities, especially in performing general selection tasks and the benefits of using an expert systems approach to solving domain specific problems. An attempt is made to establish the reason why expert systems usage in solving purchasing problems is a rare occurrence. It is hoped that, at the end, the prospects of using expert systems technologies for the selection and evaluation of suppliers would be revealed.

3.1 THE PROCESS OF VENDOR SELECTION

Paulden [1977] believed that the majority of manufacturers paid little attention to their suppliers, and suggested that a great deal of effort be invested in the selection of the firms that are to provide vital components and materials, because if too much was taken on trust initially, then the loss of time subsequently in putting things right could represent a much more serious cost. His fifteen point plan to help solve the problem is:

* have alternative sources

* design for multiple sourcing

* evaluate reliable supply

* buy from known and proven suppliers (customer loyalty)
* visit the plant and see what they are doing
* delegate specialist buyer responsibilities
* maintain close relationships (socialise with the vendors)
* check their previous transactions
* design simple warning signals
* keep buffer stocks
* check the suppliers' stocks
* reserve the right to cancel
* increase chances of being self reliant
* have contingency plans
* gain a reputation for honesty.

Some manufacturers attempted to solve this problem in various ways by applying such modern manufacturing methods as MRP (Materials Requirements Planning), JIT (Just-in-Time), OPT (Optimized Production Technology), etc.. Heinritz et al. [1986] commented that most modern companies preferred to do business with suppliers who had similar technologies, or who operated similar production methods. In other cases, many companies involved the potential suppliers at the initial stage of introducing new technologies or new products, and then urged them to help in order to ensure successful introduction and subsequent applications. For instance, to successfully implement JIT, a manufacturer would have to arrange with the supplier(s) for frequent deliveries whenever parts were needed on the production line. Those suppliers who could not keep up with this initial request would be eliminated.

Some purchasing departments have devised a form of point scoring system for the selection and evaluation of prospective vendors. For example, on one of the visits made to a manufacturing company, the purchasing manager of Armco Industries (Mr. Bob Higgs) described a point scoring system of vendor selection which is used by his organisation. Figure 3.1 demonstrates how the point scoring system is constructed. The factors were allocated different weighting values in the form of the maximum number of points for that factor. These factors and their rated values were meant to represent the organisational priorities [Dobler et al. 1990]. For instance, a firm might consider the delivery dates more important than the production methods or vice versa, in which case, different rating values are assigned appropriately. In product pricing, the fewer the points a vendor scores indicates that his prices are less competitive. At the end of the analysis, therefore, the vendor with maximum points is selected. See figure 3.1 overleaf.

Figure 3.1 Vendor Rating Sheet for Point Scoring System.

FACTORS	% RATING (MAX. POINTS)	VENDORS		
		X	Y	Z
Product specification	10	8	10	10
Product quality	12	11	11	12
Delivery dates	12	10	11	11
Product prices	10	10	9	8
Technical competence	10	8	8	10
Management efficiency	10	9	9	9
Production method	5	4	5	5
Plant capacity	8	6	7	8
Financial status	10	8	8	10
Honesty	6	6	5	5
Value added services	5	3	5	5
Others	2	1	0	1
Total rating	100	84	88	94

In the above example, vendor Z scored the highest points, and therefore, was selected. Where more than one vendor has an equal number of points as in figure 3.2, the Priority Rule applies. This means that the factors would be considered individually, and the vendor with the better score on the factor with the highest priority values would be preferred. In this case, vendor W was chosen instead of Z because the factor "Delivery Dates" had higher priority than the factor "Product Price". See Figure 3.2.

Figure 3.2 Vendor Rating Sheet.

FACTORS	% RATING (MAX. POINTS)	VENDORS			
		W	X	Y	Z
Product specification	10	10	8	10	10
Product quality	12	12	11	11	12
Delivery dates	12	12	10	11	11
Product prices	10	7	10	9	8
Technical competence	10	10	8	8	10
Management efficiency	10	9	9	9	9
Production method	5	5	4	5	5
Plant capacity	8	8	6	7	8
Financial status	10	10	8	8	10
Honesty	6	5	6	5	5
Value added services	5	5	3	5	5
Others	2	1	1	0	1
Total rating	100	94	84	88	94

Heinritz et al. [1986] maintained that the following five stages occurred during the actual process of vendor selection:

* The survey stage - which explores all possible sources of a product.
* The enquiry stage - in which the relative qualifications and advantages of potential sources are analysed.
* The negotiation stage - where arrangements such as discounts, warranties, etc., are discussed.
* The selection stage - in which the actual choosing of vendor(s) is done and

orders are placed.

* The experience stage - in which the assessment of performance, relationships, etc. are observed.

Having established all the possible sources of supply, an initial screening needs to be performed in order to narrow the list down to the acceptable sources. The criteria for this first elimination process may be based on the location of the source, due to the fact that the longer the distance (ie. from source to destination of the product), the riskier the transaction (and perhaps costlier when taking into account the transportation cost). The acceptable sources are then studied, with emphasis directed towards acquiring more specific knowledge about the vendors' production facilities and capacities, product quality, financial stability, technical competence, manufacturing efficiency, general business policies, progressiveness, position in the industry, interest in the buyer's orders, general attitude, etc.

The purpose of the study at this juncture is to identify the vendors:

* who are capable of producing the required quality and quantity of the items
* who can be relied on as a continuous source of supply under all conditions
* who will keep delivery promises and other service obligations
* who are competitive on prices.

An example of a vendor rating capability survey sheet (as figure 3.3 depicts) was extracted from Heinritz et al. [1986:100] who also introduced a more complicated rating system for vendor evaluation and selection which they referred to as Incoming Material Rating. Figure 3.4 shows a mathematical vendor rating formula that Heinritz [1986] put forward as being in use by the purchasing department of a large manufacturing company.

Figure 3.3 provides a general guideline with respect to the type of information required about vendors by the enquiry team (ie. the buyers). Normally, these requirements differ between organisations due to the fact that some firms might pay more attention to information about product quality, some to price information, some to delivery and deadlines, etc., and therefore will influence the way the vendor capability survey questionnaire and vendor rating report are designed. See figures 3.3 and 3.4 overleaf.

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Figure 3.3
Source; Heinritz et al. [1986] p.100

Calculating the incoming material rating was based on experience with a single product when procurement of that product is under consideration. The formula assumes that:

* the evaluation of vendor's performance has to address all three major purchasing factors - quality, price and service
* the relative importance of these factors differs in relation to different items.

Weights were assigned to each item, depending on its criticality to the organisation. The values were then added up to make an overall weighting factor of 100 points. The assignment of these weights was a matter of judgment. For example, one could assign the 100 points to three factors in this order: 45 points to quality, 30 points to service and 25 points to price.

The quality rating could be worked out to represent the percentage of the number of acceptable lots out of the total lots received. For instance, if 500 items were received, and 465 of those items were acceptable, then the quality rating would be 93%. The service rating could equally represent a direct percentage of the items received as promised, in respect to the total lots received, ie. if 200 items are delivered as promised out of a total scheduled delivery of 250, then the service rating would be 80%. In price rating, the lowest price from any vendor was assigned 100 points, and the prices from

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Figure 3.4
Source; Heinritz et al. [1986] p.105

other vendors were rated in inverse ratio to that figure. For instance, if the lowest price from one vendor is £1.99 per item, and another vendor's price is £2.10 for the same item, then the vendor with the price of £2.10 would achieve the price rating of 100 x (1.99/2.10) = 94.8%.

In the above example therefore, the total quality rating would be 45 x 93% = 41.85%, the service rating will be 30 x 80% = 24%,
and the price rating will be 25 x 94.8% = 23.7%. This calculation method is illustrated in Figure 3.4.

Woodside and Möller [1992] emphasised that in the process of supplier selection, the selector's choice heuristics usually include one or some combination of the following judgmental rules:

* **The Compensatory Models.** In this case, the decision maker assigns a weighting factor to every attribute, and then evaluates the alternatives (ie. other potential suppliers) according to the amount of each attribute they possess. The weighted attribute scores are then added up and the final preference is, thus, made.

* **The Satisficing Models.** These can be either conjunctive or disjunctive models. In the conjunctive model, a "bench marking" system is applied and every supplier is required to exceed established minimum levels (threshold) for

each attribute. The conjunctive process therefore classifies the suppliers into acceptable and unacceptable categories without defining a complete preference order. The preference order will be achieved eventually by extending the goal-post of the attribute requirements (eg. price) until only one (or the required number) of the suppliers remains acceptable.

* The **disjunctive model** is the case where the decision maker picks one supplier attribute with high value (such as a certain quality specification), and the suppliers who do not meet the required minimum value on that specified attribute are categorised as unacceptable.

* The **Lexicographic Models**. This assumes that the evaluation of potential vendors is made by comparing them on the basis of the most critical criterion (or attribute), and then selecting the best supplier. If more than one (or the desired number) of vendors achieve equal marks (or points), then another comparison will be performed based on the next most critical attribute. The process continues until preference is established. This view was supported by Dobler, Burt, Lee [1990], Heinritz, Farrell, Smith [1986], Compton [1982] and Kennedy [1992].

However, the nature of the choice model to be adopted when confronted with the vendor selection problem is influenced by the following, according to Woodside & Möller [1992]:

* the number of vendors from which preference is to be made

* the number of attributes

* the differences between the suppliers

* the newness of the situation

* the technical and/or the commercial importance of the situation, and

* time pressure.

If, for instance, there are many vendors and many attributes to be considered, the tendency to adopt more than one model will exist - with the satisficing model being a first stage elimination rule. In a situation where there are relatively many vendors and/or many attributes, no time-pressure and the situation is a new one, then the Compensatory / Lexicographic models for preference ordering would be applied. Where few attributes and suppliers are to be evaluated, and there exist differences between vendors, time pressure and familiarity of the situation, then a conjunctive model should be favoured.

3.2 COMPUTER USAGE

According to a study on the use of computers in purchasing conducted by Parasuraman [1981] in the United States of America, 53% of the purchasing personnel interviewed confirmed that they used computers in some aspects of purchasing activities. The study also revealed that larger companies (ie. in terms of the number of employees and the volume of sales) had more of a tendency to use computers in performing purchasing tasks. 62% of the firms with less than $25 million in sales volume did not use computers whereas only 24% of those firms with more than $25 million sales did not use computers.

An article by Trecha and Helferich of Dialog Systems Division of A.T. Kearney Inc. in U.S.A. (Trecha & Helferich [1988]) found that as at 1985, more than 70% of the purchasing departments interviewed were automated. They maintained that apart from using computers to accumulate, process, store and retrieve purchasing data (ie. transaction based systems), purchasing organisations were beginning to equip their buying personnel with automated tools which provided for decision support and expert assistance.

Research conducted by Plank et al. [1992] in two regions of the U.S.A. on the impact of computer usage by purchasing revealed a great increase in the use of computers by purchasing departments since the earlier studies. This study revealed a 98.2% computer usage rate in performing purchasing activities. Hence from 53% usage rate in 1981 (Parasuraman 1981) to 98.2% in 1992 (Plank et al 1992), showing an increase of 45.2% over a period of eleven years.

Table 3.1 overleaf illustrates the percentage (%) usage of computers in various purchasing activities.

Table 3.1 PURCHASING ACTIVITIES AND COMPUTER USAGE (%)

TYPE OF ACTIVITY	% COMPUTER USAGE
Maintaining Vendor List	89.9
Maintaining Inventory Records	87.3
Monitoring Purchase Order Status	77.9
Preparing Purchase Orders	76.3
Preparing Correspondence and Memos	65.8
MRP	61.8
Budgeting	56.6
Keeping Vendor Performance Ratings	44.7
Monitoring Quotes & Competitiveness	14.5
Respondents Using Computers for at least one Function	98.2
" Using Computers for all Functions (5 of 107)	4.7

Source_ Plank et al. [1992]

The result of the study by Plank et al. also reinforced Parasuraman's [1981] findings that large companies still make more use of computers than small ones. However, smaller companies use computers a lot more at the present time than in the past. Again 55% of the purchasing professionals polled claimed to have a computer or a terminal at their desk. Others revealed that they have easy access to a computer or a terminal.

Advances in information technology systems have helped to enhance the management of the purchasing and supply chain. The use of EDI (Electronic Data Interchange) has made a significant contribution to the managerial capabilities of the purchasing organisation and to improving the communication between purchasing, manufacturing, and vendor systems. EDI allows information and documentation to be transferred from the buyer to the seller, ie. data/information from the buyer's computer systems to the seller's computer systems. The Caterpillar Tractor Company uses an EDI system called SPEED, according to Vollmann et al. [1988]. Nearly four hundred of the company's suppliers are connected to SPEED and they electronically exchange data. The use of EDI is more appropriate in situations where some form of relationship already exists, eg. between the buyer and the seller. Marks and Spencer (a retailer with chain stores) also uses EDI to exchange data with its existing suppliers. It is in fact a standard requirement for all Marks and Spencer's suppliers to install the equipment and then connect to the EDI service.

Only two out of the one hundred and seven respondents of the Plank et al. [1992] survey indicated some activities in the application of Expert Systems to purchasing, and only one of them was reported to be operational. The question as to why that was the case came to mind. At this stage of the research programme, one can only speculate that the reason may be because the purchasing organisations and/or the purchasing personnel believe that expert systems have limited use in solving purchasing problems, or alternatively because they have little or no knowledge of Expert System technology and its versatile applications. Further investigation into this matter was pursued as the main body of the work described in this thesis. At this point therefore, it is deemed appropriate to provide an acceptable definition of the subject - Expert Systems.

3.3 DEFINITION OF EXPERT SYSTEMS

Expert Systems is an offspring of Artificial Intelligence (AI)

It is common knowledge that human beings solve problems in different ways. It is also common for people to think when they are trying to solve difficult problems or make important decisions. This thinking process, according to Nickerson et al. [1985], is a feature of man's intelligence. Levine et al. [1990] believe that when the thought processes are studied and then broken down into basic steps, and a computer program that solves problems using these same steps is designed, then Artificial Intelligence (AI) is born. They try to define AI as being simply a way of making computers think intelligently, and argue that AI provides a simple, structured approach to designing complex decision-making programs. Laurière [1990] argues that any problem for which no algorithmic solution is known is a problem in AI.

By contrast, most authors of AI texts and publications avoid delving into defining the subject because, they say, AI has no clear cut definition.

Edwards [1991:5] distinguishes six different areas of AI as being:

1) Knowledge-Based Systems (KBS) or Expert Systems, as they are termed in this thesis
2) Natural Language Understanding
3) Pattern Recognition
4) Intelligent Computer-Assisted Learning
5) Speech Recognition
6) Models of Human Cognition.

See figure 3.5, the AI Classification in page 50.

BRANCHES OF ARTIFICIAL INTELLIGENCE

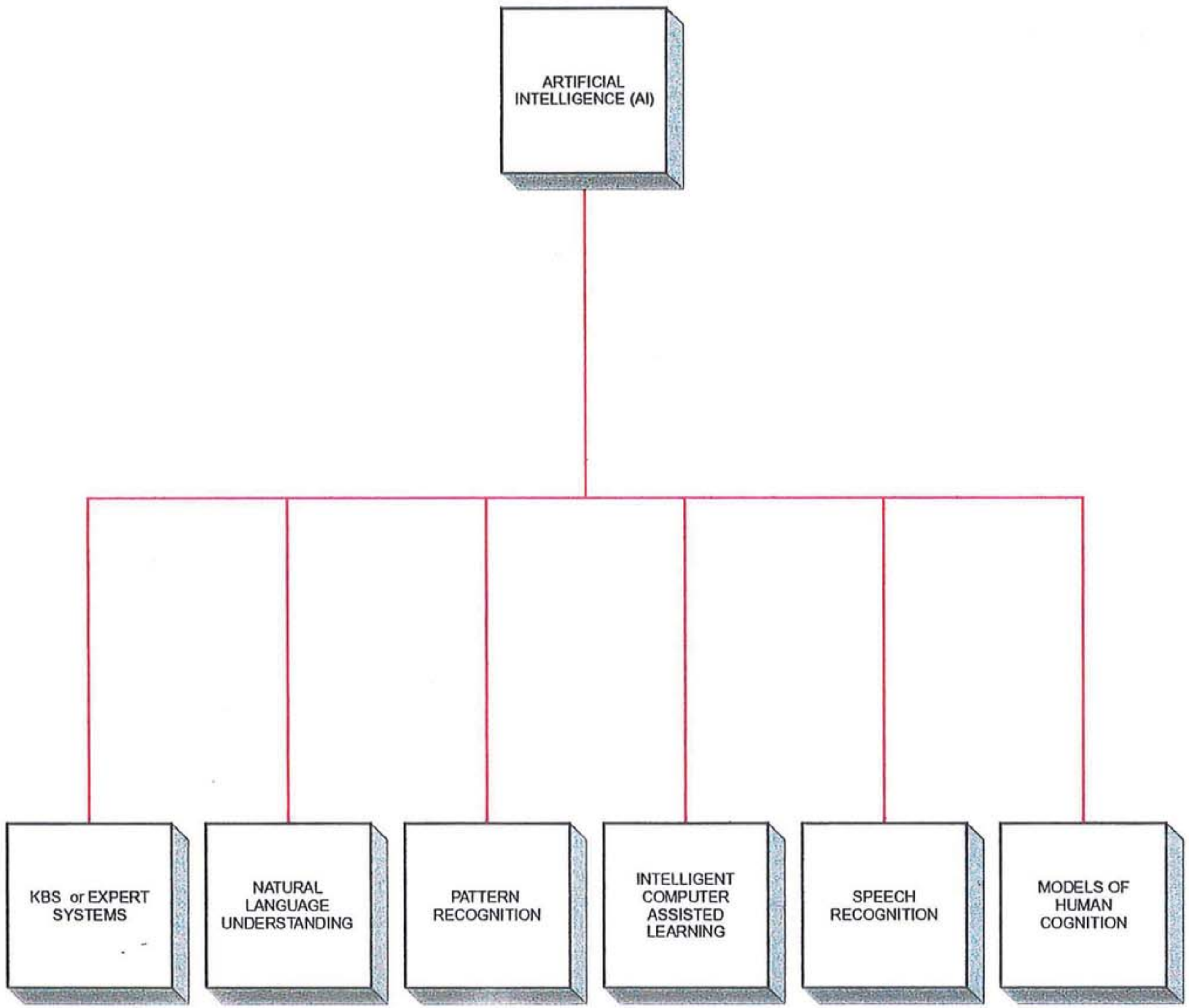


Figure 3.5 AI Classification

The topic of this thesis is Knowledge-Based Systems, or rather Expert Systems, and as such, the other areas of Artificial Intelligence are not discussed further. Nevertheless, they are worthy of mention because they all share a common root with Expert Systems, as depicted by figure 3.5.

The earliest AI Systems were intended as general problem solvers; whilst much was learnt from these, they were not terribly successful in this activity. The emphasis thus shifted to research intended to mimic the performance of a human expert in a narrow, well-defined domain.
---- [Edwards 1991:7] ----

The approach underlying the development of expert systems was due to the inability of the early systems to consistently solve complicated problems.

According to Luger & Stubblefield [1989;15], *"This was due to the ability of any reasonably complex logical system to generate an infinite number of provable theorems: without powerful techniques (heuristics) to guide their search, automated theorem provers proved large numbers of irrelevant theorems before stumbling onto the correct one. In response to this inefficiency, many argue that purely formal, syntactic methods of guiding search are inherently incapable of handling such a huge space and that the only alternative is to rely on the informal, ad hoc strategies that humans seem to use in solving problems".*

Expert Systems can be described as a type of analysis or problem-solving model, almost always implemented on a computer, which deals with problems the way a human expert does. It involves the process of:

* eliciting specific experience and knowledge from the human expert(s),

* coding the acquired knowledge and experience of the human expert(s) into a

computer readable form,

* storing the coded knowledge in a knowledge base, and

* consulting the knowledge base as and when required to solve specific problems or to offer advice on related issues.

An Expert System is defined by the British Computer Society Specialist Group on Expert Systems as

"an embodiment within a computer of a knowledge-based component from an expert skill [such that] the system can offer intelligent advice or take an intelligent decision about a processing function" [Edwards 1992:114].

The solution process includes consulting the base of knowledge to heuristically develop an answer based on the characteristics of the problem.

Theoretically, unlike conventional computer programs but quite like human experts, an Expert System has the ability to justify its own line of reasoning in a manner directly intelligible to the enquirer. One method used to attain these reasoning characteristics is known as rule-based programming. The rules are in the form of IF... THEN..., ie: IF <condition> and <condition> and... THEN <conclusion> and <conclusion> etc. where all conditions and conclusions are statements with a truth value. The condition is also called the antecedent while the conclusion is also known as the consequent, ie: IF <antecedent> THEN <consequent>.

Such rules are known as IF... THEN... rules or production rules. These rules can be used to construct powerful inference systems by being combined into networks in which the consequents of some rules (or parts of the consequents) are antecedents of other rules (or parts of those antecedents). Figure 3.6 overleaf demonstrates an example of a rule network where:

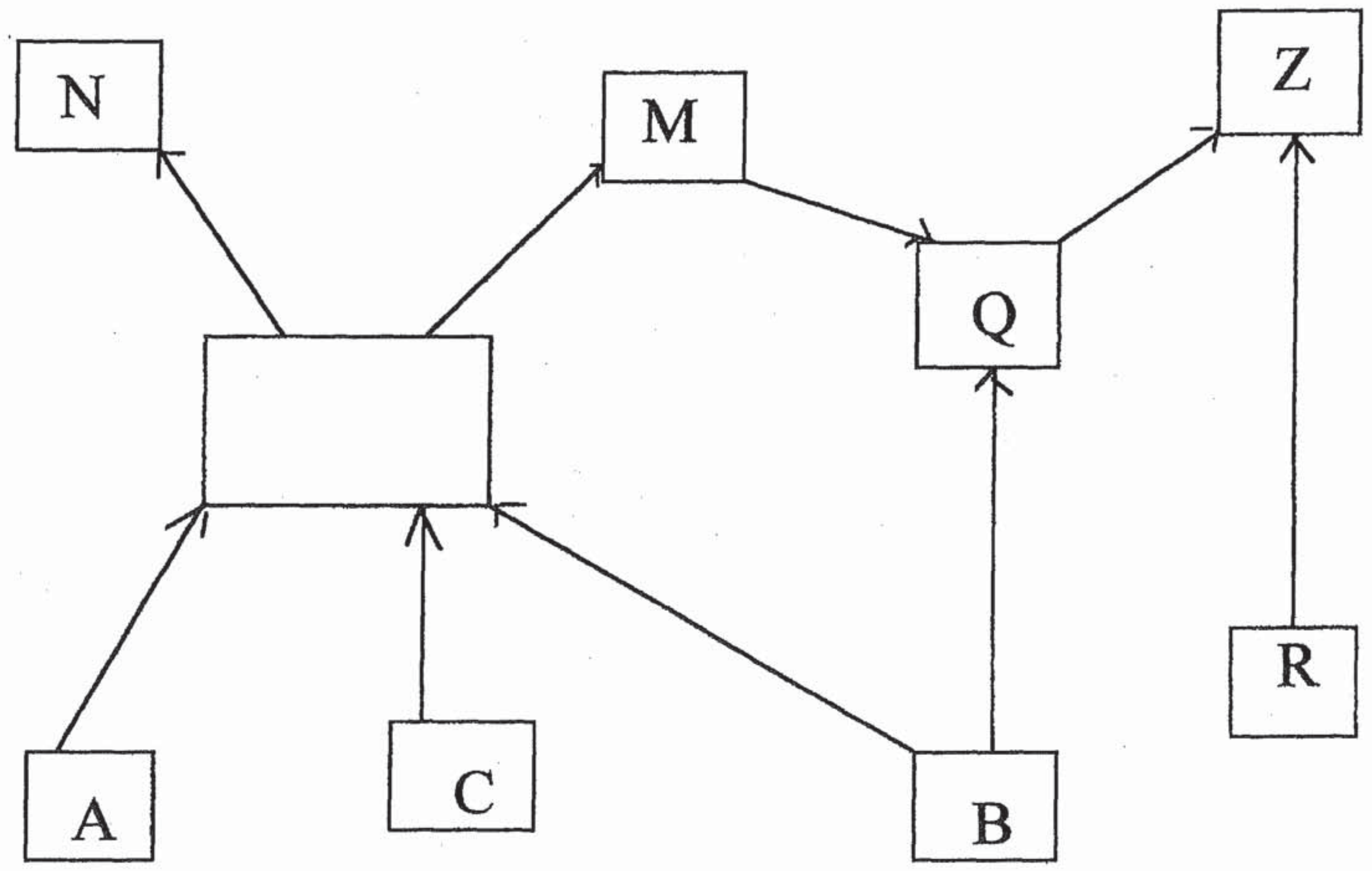
if A and B and C then M and N

if B and M then Q

if R and Q then Z.

See figure 3.6, the Rule network in page 54.

FIGURE 3.6 RULE NETWORK



An Expert system can be summed up as a rule-based AI application program for doing a task which requires expertise [Charniak, McDermott:1985]. Many different schools lay claims on Expert Systems. For instance, the Computing School believes that because an Expert System is implemented on a computer system(s) (ie as a computer program), it is a computer science discipline. The Psychology School argues that since an Expert System is to do with the simulation of human behaviour, ie.

* the way we think

* the way we solve problems

* the way we acquire, manipulate and dispense knowledge

therefore, it is a psychology module.

The Business, Engineering, Medical Schools, etc all hold their claims on the area of application of the technologies of Expert Systems.

It does not really matter whichever school wins the argument. The researcher acknowledges the fact that, as far as this research is concerned, it is dealing with a behavioural phenomenon, captured and simulated with a computer system for use by business organisations to enhance performance. Therefore, the Psychology, the Computer and the Business schools are all winners in their respective rights.

3.4 EXPERT SYSTEMS COMPONENTS

An Expert System has three basic components, namely:

1) Interface

2) Knowledge Base

3) Inference Engine

The Interface:- this refers to the point at which both human and non-human interactions with the system take place.

The Knowledge Base:- this is where the facts and data relevant to a specific application are stored. It is accessed by the inference engine in the course of reasoning out a problem.

The Inference Engine:- in conventional computer programs, algorithms are used to organise data files and choose records. Expert System programs too need a mechanism for selecting which rule (ie. in a rule-based system) to fire and in what order. The knowledge base contains the knowledge (eg. the facts and rules) about a defined problem domain but not information on how to find the rules that apply and when to evaluate them. It is the inference engine that processes the knowledge base in this way.

3.5 APPLICATIONS OF EXPERT SYSTEMS

An Expert System is not the only solution to any specific problem. It is an approach to solving a domain problem, or it can assist a solution process. An Expert System can be used in areas where:

- human experts are in short supply
- there is no algorithmic method of solving problems
- data is noisy
- diagnosis is required
- configuration is required, etc.

so that it can offer:

- advice
- consultancy service
- assistance in decision making, etc.

Every organisation that uses expert systems technologies to solve problems has its own reason(s) for doing so. For example, Kraft of Digital Equipment Corporation (DEC), one of the pioneers of the use of expert systems in practice [Kraft:1985] said that the reasons why DEC was supporting expert systems were:

- financial benefits - that most of the projects carried out by DEC paid for themselves

- that difficult problems are solved using expert systems

- to capture the rare knowledge and experience of human experts in a specified domain and put them to use for other defined people.

One of the best known expert systems was called XCON, which was used by DEC to configure DEC computers and which addressed the problems of:

- incomplete orders
- inaccuracies
- inconsistent configurations
- disagreement between engineering and manufacturing - ie. to correct discrepancies before sending the design for final manufacture. etc.

DEC used expert systems in every function of its business operations in what it called its Knowledge Network [Arnold Kraft:Alvey Video 1985]:

XSEL For sales (Expert Selling Assistant)

XCON For engineering (ie. for specified configuration)

IBUS For manufacturing (using IMACS and ISA)

IMACS - Intelligent Manufacturing Assistant Computer System

ISA - Intelligent Scheduling Assistant

XSITE For customer service, etc.

Very little research work has been conducted in the area of using expert system technologies for the selection of vendors, according to the literature survey carried out for this research. In fact, only one published work has been found by Vokurka et al (1996) of Texas A&M University. This described a prototype expert system for the evaluation and selection of potential suppliers. This was more of a descriptive model and did not explore in depth all the many factors which organisations consider in the process of supplier selection. The work of Vokurka et al [1996] is a prototype; not yet fully developed and hence, not operational. It is more of a general application and not specific to any industry or organisation. However, the publication highlighted global awareness of the growing relationships between organisations and their suppliers.

The lack of published work relating to expert systems for vendor selection is significant, giving that much research and development work has been carried out in the application of expert systems for selection in general. Illustrative examples of the published work on expert systems for selection include:

EXPERT SYSTEM FOR TILLAGE SELECTION

Developed for selecting tillage alternatives for corn and soybean production in Ontario, Canada, by Clarke, McLeish and Vyn [1992].

LARS

An expert system for laboratory reactor selection. A rule-based system within a frame structure, developed by Hanratty, Joseph, and Dudukovic [1992] at the Chemical Reaction Engineering Laboratory of Washington University, Saint Louis.

RSES

An expert system for respirator selection was designed to assist the user in the selection of a respirator for a specific application, by DeArmon [1992]. RSES was developed because the National Institute for Occupational Safety and Health (NIOSH) in Ohio issued a guideline on respirator selection. The system would also provide industrial hygienists and other professionals with a procedure for selecting suitable classes of respirators for particular concentrations of specific contaminants.

ES/ADVISOR

A prototype expert system to assist in the selection of expert system development tool for engineering application developed by Mills, Erbas, Hurmuzlu & Tanik [1992].

ESPEM

An expert system for the selection of phase equilibrium model, designed to assist in selecting suitable vapour-liquid equilibrium thermodynamic models according to specific operating conditions developed by Chen and Chang [1992] (Department of Chemical Engineering, Nation Taiwan University).

ONLINE-EXPERT

An expert system for online database selection; developed by Zahir and Chang (Canada) in 1992. This is a prototype that is designed to provide the user with advice on the selection of database.

CRISEBOOK

An expert system developed to assist the chromatographer in the selection of suitable optimisation criteria. It was developed in Brussels in 1992 by Bourguignon, Vankeerbeghen and Massart [1992].

ADVISOR

An expert system for the selection of courses developed at the Pennsylvania State University by Kamarthi, Valbuena, Velou, Kumara, and Enscore [1992]. This system was designed to recommend to undergraduate students the best possible combination of courses that each student has to take in order to complete his/her degree in the least possible length of time.

EXPERT SYSTEM FOR MACHINE SCREWS SELECTION IN ENGINEERING DESIGN.

This system was designed by Chen, Yan and Shine [1992] as an online consultant to give the less experienced engineers advice on selecting suitable machine screws for their product design.

EARTH-MOVING E.S.P.

This is an expert system developed by Amirkhanian and Barker [1992] for the selection of equipment for Earth-Moving operations.

CONTEX

An expert system for contingency selection proposed in Germany by Schafer, Schwartze and Verstege [1991].

GRIPPEX

An expert system for selecting Robot Gripper Types, developed by Pham and Taggin [1992] (both from the Electronic and System Engineering Department of the University of Wales in Cardiff) to assist the manufacturing engineers with the selection of appropriate grippers for a robot.

EXPERT SYSTEMS IN PURCHASING

The literature reveals that there are only four papers on expert systems in purchasing. The one reported by Vokurka et al (1996) is a prototype expert system which has already been mentioned in page 59. The other three address other purchasing tasks.

Velazco [1990] describes the feasibility studies conducted by the United States Navy supply Centre. The project was undertaken to demonstrate the usefulness of Expert Systems in the procurement process then in use at the Navy Supply Centres throughout the world.

The aims of this project included:

* the standardisation of the screening process
* the design of a user friendly system
* the design of a flexible system
* the design of a system that would train or instruct new employees as well as simplify the job of the more experienced screeners.

The prototype expert system was developed with EXSYS professional (an expert system shell) and a Compaq portable 386 plus some use of AT & T 6300 desktops. It can run on any IBM compatible machine. However, there is no indication that the full system was ever completed or used by the US Navy.

Dillard et al. [1987] report on a project which was aimed at determining the applicability of AI tools to the price analysis task as carried out during the Military Procurement process. The project was supported by the United States Air Force Business Research Management Centre. The research was intended to build an Expert System based on expert price analysts' decision-making behaviour. This prototype expert system was developed with the ZOG system, a software system for organising knowledge in the form of a network of frames, - also referred to as Zognet.

The system identified, encoded, and represented within a computer system the human expert behaviour in analysing prices. On-line decision support, interactive tutorial capabilities, and requisite decision documentation are among the capabilities which the system was designed to have. Again, there is no indication that the system progressed beyond the prototype stage.

PURCHASING BUYER WORKSTATION (PBW)

This was reported by Trecha and Helferich [1988] to be using Expert System programs in performing purchasing tasks. The PBW used an Expert System to define specific courses of action based on a series of considerations when evaluating purchase decision alternatives. The Purchasing Buyer Workstation is a larger program that uses the Transaction Processing, Decision Support

System (DSS), Expert Systems and Productivity Software technologies. In this case therefore, the Expert System is embedded within the larger system, and designed to address issues concerning:

Commodity availability

Supplier stock programs

Material buy-back

Market characteristics

National supply trends

Design specification

Supply assurance

This expert system was used as part of a comprehensive package to help solve the purchasing problems listed. It was not designed to address issues relating to the selection and evaluation of potential suppliers. Nevertheless, more than any other reported work, it does demonstrate the potential for the use of expert systems in purchasing decisions.

3.6 THE BENEFITS

As previously mentioned, an Expert Systems approach is only one of the many available tools for solving domain specific problem(s). In organisations where they are used, Expert systems must offer sufficient benefits, otherwise those organisations would most probably not consider the technology. Naturally, all organisations have their individual reasons for using Expert Systems technologies. Expert Systems not only perform the primary function for which they are developed, such as selecting machine screws in engineering design developed by Chen, Yan and Shine [1992], selecting database(s) by Zahir and Chang [1992], selecting equipment for earth moving operations by Amirkhanian and Baker [1992], etc., but they also provide other benefits, among which are:

. Making knowledge available.

The knowledge and experience of human expert(s) in a defined domain application are acquired and preserved so that they can be consulted to solve related problem(s). This is referred to as "rare skill archiving" by Kraft [1985]. In many cases, business problems arise through ignorance. Some organisations, for example, suffer because they do not know how to solve certain purchasing or production problem(s), or what causes the problem(s) they are suffering, or how to get help. The information they require may be available, but hidden in the head of a professional. With the expert system, the necessary information or knowledge is acquired from the professional and made available to those concerned, hence providing the solution to the particular purchasing or other defined problem(s).

. Training the domain personnel.

Since it is the knowledge and experience of the human expert(s) that is preserved and called up to address related issues, the novice personnel can therefore gain the knowledge and experience by observing how expert systems tackle problem(s). As the novice buyers are guided and trained by the system, their performance is enhanced as though they were very knowledgeable and experienced, hence improving their productivity. As Trecha and Helferich [1988:31] put it in their discussion of the Purchasing Buyer Workstation:

> *By introducing the expert knowledge of the seasoned buying professional into the every day procurement operation provides the ability for the novice buyer to perform in an experienced mode. This mode has proven to provide legitimate cost and productivity savings as a result.*

Velazco [1990] reported that his "Expert System that joined the Navy" would train or instruct new employees as well as simplify the job of the experienced ones, and this is reinforced by DeArmon and Liuo [1991] in their report on the Expert System for Respirator Selection. Dillard et al. [1987] too shared the experience that expert systems provide training tools for the domain personnel.

Usually, most benefits of using expert systems are specific to individual situations. For instance, Arnold Kraft of Digital Equipment Corporation [Kraft 1985], stated that it supported the use because expert systems offered among other things financial benefits, and solved difficult problems. Hanratty, Joseph and Dudukovic [1992], Pham and Taggin [1992], etc., all cite the benefits of good explanation facilities. Kamarthi et al. [1992] developed ES Advisor - an expert system which advised the students of the Pennsylvania State University (USA), and recommended to them the best possible combination of courses for the students' forthcoming semester. The system performed the function as desired, and provided the additional benefit of facilitating the maintenance of students records.

An Expert System, as a form of advanced computer program, and/or a process of automating the decision making paradigm, also shares the benefits which are common to other advanced computer programs, such as:

. Accuracy of result (based on the input) and Repeatability of result.

. Less operator fatigue.

. More reliable result. Human beings can make erroneous judgments when they are tired or distracted, whereas expert systems do not make mistakes unless they are deliberately caused to do so, (ie based on the principle of "garbage-in and garbage-out" GIGO).

3.7 ORGANISATIONAL ISSUES

Presently, many companies use expert system technologies for a variety business operations. For example, Argos Catalogue, Dell (mail-order computer sales) and Cooker (electrical goods point of sales adviser) all use expert systems for accessing databases, according to Jackson [1996], Ernst & Young use a PC based expert systems for advising their clients on V.A.T. issues, etc.

The fact that expert systems have been accepted in many organisations may be attributed to the belief that knowledge is very fundamental to modern society, Rapp and Collins [1987]. McNurlin and Sprague [1989] regarded the need for expert systems as an extension of the then existing demand for computer systems. This is because the factors that create demand for improved computer systems can be extended to justify the development of a type that can process symbolic information such as Expert Systems.These factors include

- the need for new approaches to business organisation
- the need for improved productivity
- the need for expertise
- the need for knowledge
- the need for competence
- the need for automation.

The issues surrounding the use of expert systems in organisations are discussed under the following three headings, namely: Implementation Issues, Attitude Issues, and Maintenance Issues.

3.6.1 IMPLEMENTATION ISSUES

The commitment of the senior management in the organisation has to be obtained right from the conceptual stage of the introduction of an expert system. This commitment should not be allowed to waver at any stage, especially after the installation. This is because any new system that is installed for the benefit of an organisation has to be maintained and updated with new knowledge as it becomes available, Twiss [1987]. The end users of the system should also be involved because they are the ones who will use the system. If they cannot use it when it is delivered, then the system is bound to fail. Hence the top management approval and commitment as well as involvement of the end users (both in idea generation, training, testing of the system, etc.) should be maintained at every stage of the implementation.

Another focus here should be on those whose knowledge and experience are to be acquired and stored. Should the knowledge come from an employee who may be very reluctant to give away the only weapon he or she has? The knowledge and experience that make him important and respected will, as a result of the introduction of an expert system, be captured and made available to everybody in the organisation. On the other hand, he may feel excited and proud that his knowledge and experience are so superior and precious that they have to be automated and used by everybody. The latter is in fact much the more common in the literature. However, the point here is to focus on the level of co-operation that one would expect from the human experts in the organisation.

Other areas to be considered include:

- the level of usage of the system. The full potential of an expert system cannot be realised unless a high uptime is maintained.

- accessibility. The system should be made available to every user at all the required times. This implies that every system user should have easy access to the system, preferably at their desk.

- the ergonomics of the work environment. This addresses the issues of the work environment, ie. furniture and work surface layout, lighting, freedom from noise, etc. The work environment should be conducive,

etc.

- the level of user support. This includes training, a system for feedback, on-going consultation facilities, etc. A user support system should be provided for all users of the system.

- the ergonomics of the software of the expert system. This efers to the systems software, ie. the "user friendliness", the capabilities, the user interface, the menu type, the mouse system, portability, etc.

3.6.2 ATTITUDE ISSUES

Attitudes towards expert systems in particular and information technology in general vary, according to Turban [1990]. Factors that influence these different attitudes include:

- experience with expert systems
- interest in using expert systems
- willingness to retrain
- worsened unemployment; This latter attitude is shared by many people, especially those in the more repetitive jobs and those who believe that expert systems have come to take over their jobs.
- Help create jobs; The invention of expert system programs has helped create or increase jobs. This is a matter of opinion, especially when considering the type of jobs Expert Systems have created. These include knowledge engineers

or expert system developers, expert system vendors, developers and maintenance engineers of expert systems tools, etc.

- Reduce tedious tasks, and help solve problems.
- A threat to privacy. The experts whose knowledge and experience are stored in the knowledge base then share their rare knowledge and experience with every user of the system.

Expert systems, like any other computer program, could be a source of motivation. Hackman and Lawler's [1971] work on motivation established that experience responsibility and knowledge of result have a direct impact on motivation. Expert systems, like other computer programs, could provide instant results for the user to observe his or her performance. If a person is unable to determine whether his/her performance has been effective or ineffective, it is impossible for that person to experience the positive or the negative self evaluative feelings that are the essential components of motivation, Johnson & Scholes [1984] . However, continuous negative results can lead to frustration.

3.6.3 MAINTENANCE ISSUES

Once the system is up and running, it needs to stay operational. Since maintaining a system is a continuous process, there should be a system through which new knowledge could be added and a channel through which archaic knowledge could be removed whenever there is the need to do so, Twiss [1986] and Murdick & Munson [1986]. Another issue is: would the person or the system who will be responsible for the maintenance be an employee of the organisation or an outside vendor? The costs and benefits have to be evaluated.

Again, how will the system behave when there is a change in policy or in legislation which affects it? For example, RSES - an expert system for respirator selection, DeArmon [1992] was developed when a new guideline on respirator selection was issued by the National Institute for Occupational Safety and Health (NIOSH) in Ohio, USA.

The maintenance should also address the issues of both physical protection of the system from damage or theft and electronic denial of access to unauthorised users, Lucas Jr. [1986] and McNurlin & Sprague [1989]. An efficient security system should be employed to deter unauthorised access, unauthorised usage, all forms of corruption, eg. data deletion, editing, viruses, etc. Expert systems perse present no special technical problems, instead, the knowledge they contain may be especially important to the organisation.

The effectiveness of the rules and the facts needs to be examined at intervals to reassure their quality, Pederson [1989]. This is because the human expert(s) whose knowledge and experience are coded and preserved in the knowledge base still acquire more and more knowledge as days pass by. With time therefore, the knowledge and the rules in the knowledge base would become out of date. Hence, the decisions of the human expert(s) and those of the expert systems should be compared from time to time so that modifications and improvements to the rules and facts, the knowledge representation schema, etc., may be done whenever significant discrepancies are observed.

3.8 SUMMARY

To sum up therefore, the literature survey has highlighted many factors which determine a suitable supplier(s) and the procedures which organisations adopt when they are tackling the problem of vendor selection. These variables are discussed and analysed in chapter five.

It further revealed that although much research and development work has been conducted in Expert Systems for general selection tasks, there is only very little in the area of purchasing. The benefits of using Expert Systems technologies for selection, or in performing any other function are enjoyed by that particular domain application, but such benefits as making knowledge available to those concerned, training the domain personnel, etc., are usually common to all Expert Systems programs. The tasks that an expert system should be employed to address have to be clearly defined, and the commitment of the senior management and of the human expert(s), as well as the involvement of the end users have to be secured. The introduction of an expert system could change an entire organisation's ways of doing things. For example, when an organisation introduces expert system into its application, it will require a new kind of job design and job description such that the employees will be able to use the new system. This could cause an organisation to require a new kind of workforce and alter the structure of the organisation.

4. RESEARCH METHODS & METHODOLOGY

Blaxter, Hughes & Tight (1996) suggest that research methods should be considered under three successive levels, i.e.:

Research Families

Research Approaches

Research Techniques.

The Research Families consist of:

Quantitative / Qualitative research,

Deskwork / Fieldwork research,

The Research Approaches consist of:

Action Research

Case Studies

Experiments

Surveys

The Research Techniques consist of:

Documents

Interviews

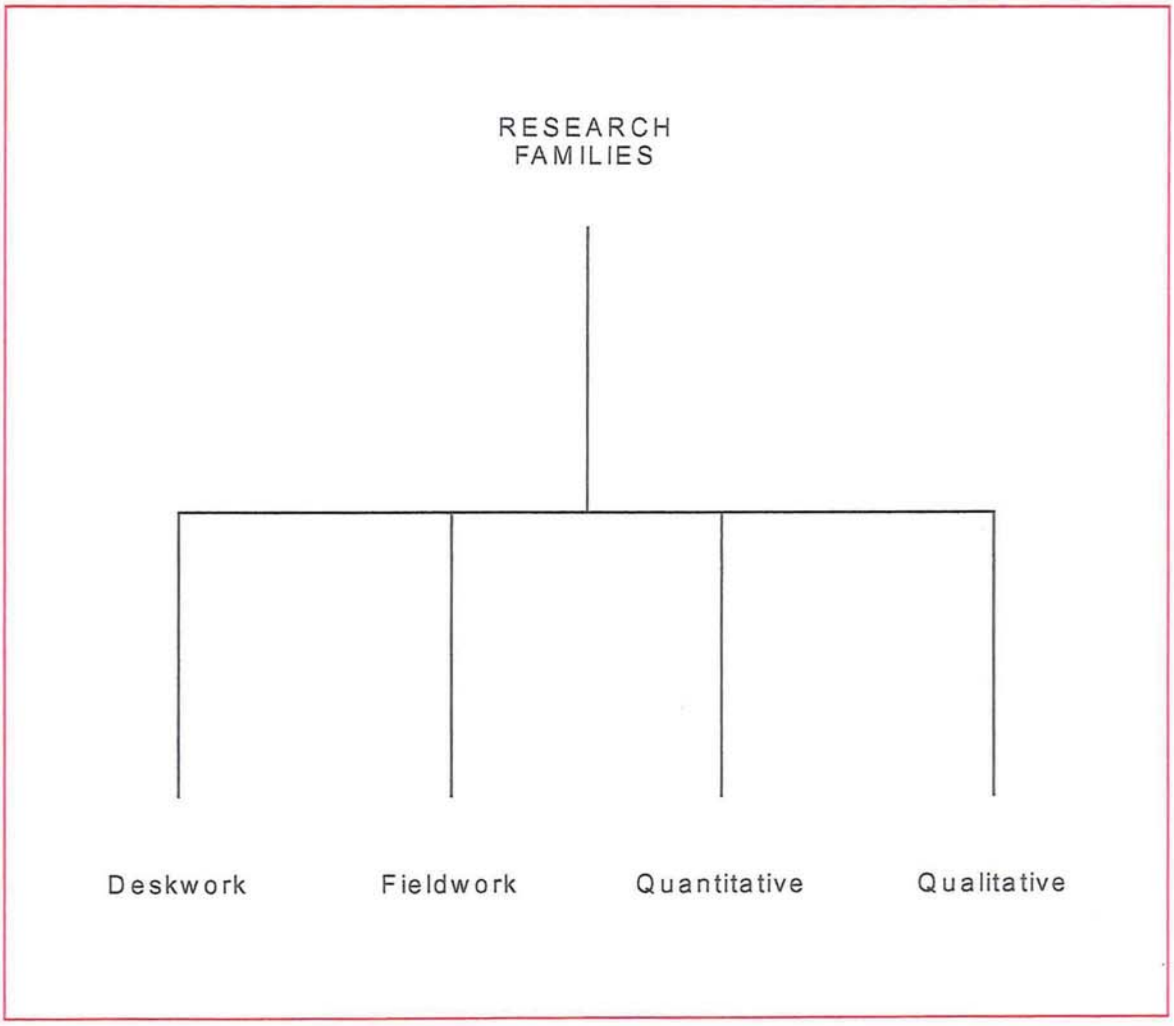
Observations

Questionnaires

They also explain the distinction between research method and methodology as being: METHOD as relating principally to the tools of data collection or techniques such as interviews and questionnaires, whereas METHODOLOGY relates to the more general philosophical issues, applicable to families or approaches.

4.1 RESEARCH FAMILIES

Figure 4.1 The Research Families



QUANTITATIVE research consists of studies in which the data concerned can be analysed in numbers. It is an indirect and abstract form of research which treats experiences as similar, and mathematically analysing them to make judgements. The use of questionnaires can be seen as a quantitative strategy whereas interviews and observations might be thought of as qualitative techniques. However, some structured and well analysed interviews could also be regarded as belonging to the quantitative family, just as some open-ended questionnaires would be regarded as part of the qualitative family.

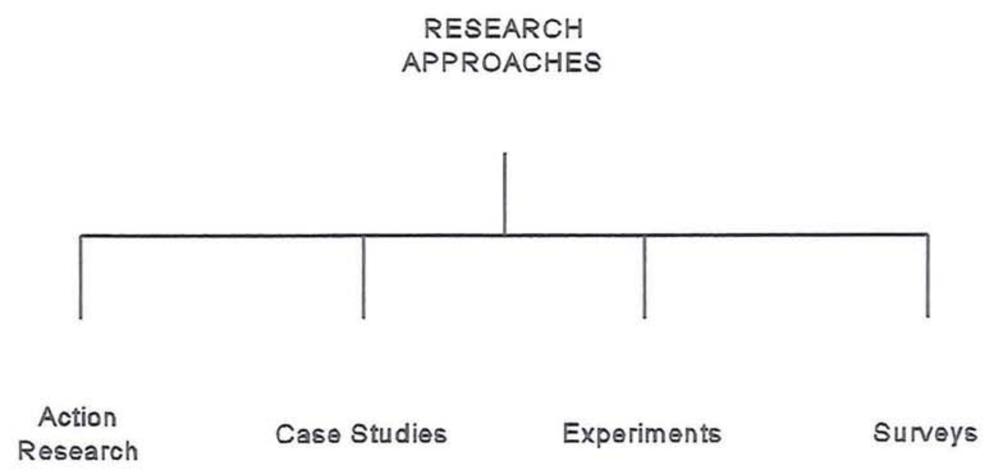
QUALITATIVE research describes events, persons, etc. without the use of numeric data. It is a method which aims to understand experience as nearly as possible. Here, events can be understood adequately only if they are seen in context. The contexts of inquiry are not invented, therefore they are natural. Qualitative research is an interactive process in which the event or object or person being studied is the one who produces or delivers materials or statements about their lives. The appraisal process, hence, is based on what was studied. Both qualitative and quantitative types of research are valid and useful, and can both be applied in one investigation.

DESKWORK refers to a process which does not involve going out into the field. It is concerned with those activities which are performed while sitting at a desk, such as literature search, writing, experiments and laboratory work, analysis of data, administration, etc.

FIELDWORK refers to the process of going out to collect research materials. These are materials (e.g. data) which could not have been accessed unless the researcher engaged in some form of expedition. This includes visiting colleagues in other organisations, attending meetings and seminars and contacting other people and organisations outside the researcher's enclave.

4.2 RESEARCH APPROACHES

Figure 4.2 The Research Approaches



ACTION RESEARCH can be defined as the study of a social situation with a view to improving the quality of action(s) within it. Action research is common with those working in professional areas with the aim of implementing the outcome of the research in their workplace in order to improve certain aspects of their own and / or their colleagues' practices. Hence, it is a research process with a practical purpose in view which can lead to change in ways of practices. The major characteristics which distinguish it from other methodologies include the fact that:

. it is founded on a research relationship in which those involved are participants in the change process,

. it involves a cyclic process in which research, action and evaluation are interlinked,

. it is problem focused, context-specific and future orientated,

. it is a learning process and hence, educative.

CASE STUDIES employ a combination of methods such as:

. personal observation; which for some periods or events may develop into participation,

. the use of informants; for current and historic data,

. interviewing, and the tracing and study of relevant documents eg from schools, government departments, travellers, museums, etc.

The case study method is also suitable for a small-scale researcher whose needs and resources come from his place of work or another organisation with which they have connection. The danger with both the case studies and action research is that researchers, particularly those in employment who are receiving support from their employers, tend to base their research focus in their places of work, thus becoming oblivious to events elsewhere. Given the opportunity, the researcher should try to see beyond his or her workplace.

EXPERIMENTS are also used as a research approach. They are at the heart of the scientific method, with its practice of formulating and testing hypotheses through carefully designed and controlled tests. Stringer (1996) highlighted that in a well designed experiment, three properties should exist, in which the researcher must:

+ vary at least one independent variable to assess its effect(s) on the subjects' behaviour,
+ have the power to assign the subjects to the various experimental conditions,
+ control extraneous variables that may influence subjects' behaviour.

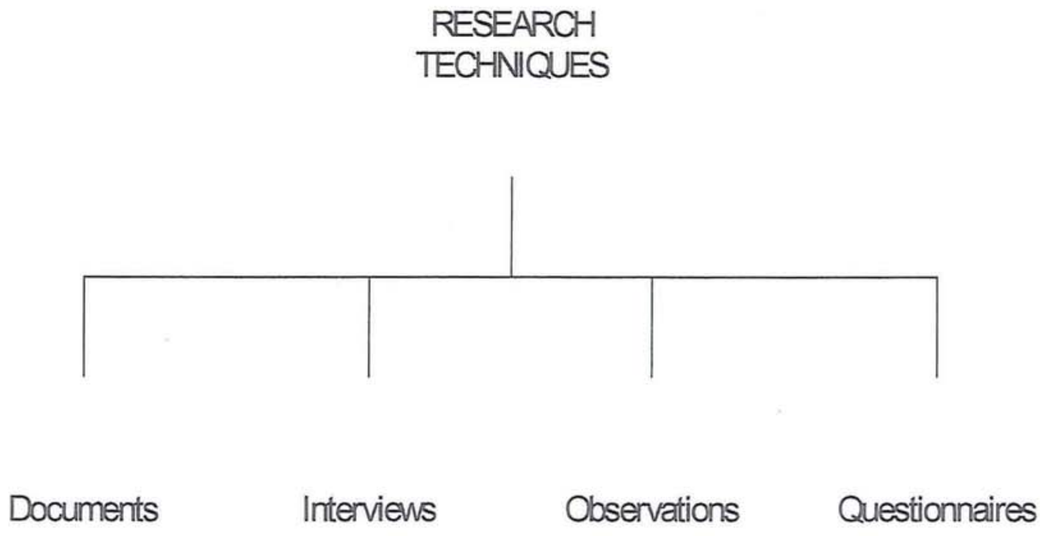
The Experimental approach involves the manipulation of the variation in one or more independent variables and the randomisation of other independent variables, followed by the measurement of the variations in one or more independent variables. The major problem for the researcher is in devising some way of controlling the variations in the variables. If the researcher could control all the variations in the independent variables, then he could associate all the variation in the dependent variable with the variation in one or more independent variables.

The term controlled variation was used to mean the proportion of the variation in the dependent variable which showed some systematic relationship with the variation in the independent variable(s). While uncontrolled variation referred to the proportion of the variation in the dependent variable which did not show such a relationship. The experimental method is ideal for the study of change.

SURVEYS are a method of collecting data by asking a set of pre-formulated questions in a structured manner. Usually, questionnaires are designed and sent to a sample of individuals drawn from a representative or defined population.

4.3 RESEARCH TECHNIQUES

Figure 4.3 The Research Techniques



DOCUMENTS; All research programmes involve, at one time or another, the use and analysis of documents. In most cases, the focus of data collection is on documents of various kinds. This can come in the form of a hard-copy (ie secondary data) of data already collected and analysed by another source, eg A company's annual report, journals, government white paper, etc. Documentary evidence is very useful as it (secondary data) complements primary data, confirms or contradicts research findings, and also keeps the researcher informed of work already carried out (or on-going) in the area.

INTERVIEWS; This method involves questioning or discussions between two people. Interviews are a useful technique for collecting primary data. They can take place over the telephone, or face-to-face at a workplace or at home or on the street. Interviews can be taped (with the permission of the interviewee) using a tape recorder, or notes can be taken during interviews. However, note taking can be distracting and hence prolong the length of the interview. This is because the researcher would be asking questions, and listening to answers, and at the same time taking notes. A major advantage of face-to-face interviews is that the researcher should be able to understand the interviewee more, with body language and non-verbal cues.

OBSERVATION; Normally observations are used to monitor events. This method requires the researcher to be involved in watching, recording and analysing the said events. Blaxter (1996) concluded that the three stages of this process involved:

(1). Recording of events in a systematic fashion as they happen

(2). Coding of the events into specified categories

(3). Analysing the events to fully describe their phenomena.

The method of observation is considered to be time consuming, since the observer will not only spend time observing and recording the events, he will later spend additional time to analyse and interpret what was recorded.

THE QUESTIONNAIRES method is widely used in social research. It can be administered in a variety of ways. Questionnaires can be posted to the intended respondents, who would be expected to complete and return them (in a self addressed stamped envelope) by themselves. For this reason, Bryman (1995) referred to them as self-administered questionnaires instead of postal questionnaires. This method can also be conducted on a face-to-face basis or over the telephone, as with interviews. Bryman (1995) also explained that self-administered questionnaires have certain advantages over other methods. In the first place, they are cheaper than interviews, especially where a large number of respondents are very dispersed geographically. They are also quicker to pilot than interviews in the sense that the questionnaires can be distributed en masse, whereas not many interviews can be conducted on the same day by one researcher. Again, in many instances, the interviewee feels under pressure by the presence of the interviewer to answer certain questions, especially those concerning social class, age, etc. Hence, this method eliminates all the problems associated with the presence of the interviewer.

The Self-administered or postal questionnaires research method is not foolproof. It has the disadvantages of low response rate and uncertainty about the true identity of the person who completed the questionnaire form, and puts more pressure on the researcher to make the research questions very clear and understandable since there would be no one to explain the questions (if needed) or answer queries the respondent might have.

Linking families, approaches and techniques does not mean that every research project would fall into just one of these classifications. For instance, one research project could make use of all of them at one point or another during the research process, while another research project could draw on only a few of them, etc. This research programme drew on almost all of them. The points at which our programme made use of these methods and methodologies are discussed below.

4.4 METHODS AND METHODOLOGIES EMPLOYED

The research methods and methodologies used in this project are discussed below and under three headings. This is because they were applied at different times and for different purposes, Beckwith et al [1993]. For instance, the methods used for collecting data are different from those used for the analysis of data, or for the program development. The headings under which they are discussed for this project are:

Data Collection

Development Phase

Systems Trial.

4.4.1. DATA COLLECTION

Part of the objectives of the research programme was to find out how organisations solved the problem of vendor selection, how informed they were about the subject of expert systems and how they would react to using expert systems technologies to help determine suitable suppliers. In order to acquire this knowledge, the following activities were conducted; discussions, literature survey, contact (via questionnaires) with people in the purchasing functions who would later be involved during the program development and testing processes, and analysis of the collected data. The methods and methodologies are explained under each activity they supported.

4.4.1.1. DISCUSSIONS

At the preliminary stage of the research process, the researcher engaged in discussions with various professionals in the business of purchasing and supply. The interviews at this stage of the research were in the form of informal discussions. The purpose was to find out whether what the researcher believed to be a problem was, indeed, perceived as such by those who were in the same profession. Further discussions with other researchers also contributed greatly as one of the means of establishing what conducting research was all about. These discussions were not structured. They usually took place at social gatherings, private homes or over the telephone. They helped in generating ideas and concepts before the more structured methods were employed.

4.4.1.2. LITERATURE REVIEW

The review of the relevant literature employed the use of documents (ie. the published materials in the subject area), documentary materials (eg. of Alvey Videos) fieldwork for data acquisition, and deskwork. Hence, conducting the review of the relevant literature required employing the features of two of the research families (ie. Fieldwork and Deskwork methodologies) and one technique (ie. Documents methods) as described earlier in the chapter. The reviews of the relevant literature exposed the volume of work which had been carried out in the subject area. Chapter three of the thesis discussed the literature review in full detail.

4.4.1.3. QUESTIONNAIRES

The structured questionnaires were more used than any other method for data collection during the research process. They were designed to capture first hand knowledge from the people who actually perform the task of vendor selection in organisations. Designing the questionnaires is a difficult task.

In the first place, the researcher had to establish:

. the questions to ask,

. how to formulate the questions and make them simple to understand and answer,

. how to select the intended respondents.

Two different sets of questionnaires were used during the research process for different purposes. For the moment, it is appropriate to concentrate on the first set, which was intended to capture data on:

. how people in purchasing and supply function performed the task of vendor selection,

. the factors they considered in the process of vendor selection,

. the factor(s) they deemed more important, and the less significant ones

. the awareness of expert systems within the purchasing and supply function,

. the general usage level of computer technology in performing purchasing tasks

. their attitude towards the idea of using expert systems technologies to help solve the problem of vendor selection, etc.

In establishing and formulating the questions to be asked, the researcher had to, in the first place, determine the knowledge which the answers to those questions should draw out. For instance, to ascertain whether a respondent knows what an expert systems program means, the question could read " Do you know the meaning of expert systems?". Some respondents may find this type of questionning too direct and unconfortable (as a direct test of their knowledge), and therefore provide less reliable or unreliable answers.

Experience had taught the researcher that many respondents feel unconfortable to admit ignorance when confronted. To avoid the embarrassment that this type of questioning could cause, a great deal of effort was invested in making the questions 'user friendly'. Hence, the question " Do you use expert systems technologies?" was preferred, and then a list of reasons (for not using expert systems) including: "your organisation has little knowledge of E.S.", "No qualified professional to spearhead the implementation of E.S.", etc was provided. See question 9 in the appendix 1.

4.4.1.3.1. THE POSTAL SURVEY

Five hundred of the first set of the questionnaire were produced and sent to five hundred organisations by post. This method, as mentioned earlier, is also called a self-administered questionnaire. The postal system was considered to be cheaper than face-to-face interview or using the telephone. Each questionnaire was sent in a stamped self addressed envelope for returning the completed questionnaire form. Five of the respondent organisations were business associates while the others were selected randomly from company directories called COMPASS and the Business Pages. These directories list the names and addresses of companies in the United Kingdom as well as the products or services which each company offers. In cases where the names of the purchasing managers were known, the envelopes would carry their names, otherwise the addressee would be: The Purchasing Manager.

The postal system of data collection was used because it was cheap, and it allowed the respondents time and no pressure to complete the questionnaire. As Blaxter et al (1996) put it, this method provided the respondents with an environment condusive to enabling them to provide honest, reliable and consistent answers.

The major disadvantage of this approach which was observed during the research programme was the low response rate. Out of the five hundred questionnaires sent out, only sixty six were completed and returned, achieving a response rate of 13.2%. Secondly, it took almost three months for the last completed questionnaire to arrive. It is possible that the response rate would have been higher if some follow-up measures had been adopted. In other words, using telephone calls or reminding letters, etc., to encourage the responses was not considered. The decision not to chase was purely to avoid putting the respondents under any form of pressure.

4.4.1.4. ANALYSIS OF DATA

The analysis of the collected data employed the use of quantitative methodology to calculate the averages, the correlations and the differences between various assumptions. The Deskwork, the Qualitative and the Quantitative research methodologies were all used for the organisation and analysis of the acquired data, and for the interpretation and presentation of the research results.

Organisations which completed and returned the questionnaires were of different sizes and types. As a result, two sets of analysis were performed. The first was to determine whether the size of an organisation influenced the way it solved the problem of vendor selection. The second set was to find out whether the type of an organisation affected its approach to solving the same problem.

In the first set of analysis, the collected data was organised and divided into five groups according to the size of the organisation. In this case, the number of employees in the respondent organisations ranged from one to more than a thousand. The European directives on business classification regarded organisations with two hundred employees and below as small businesses. Against this background, common sense also reminded us that in terms of number, one or ten people are quite different from two hundred or thereabout. One hundred or two hundred is a very large number when compared with five or fifteen respectively, etc.

Hence the more the classifications or groups of the values of an observation, Beckwith et al (1993) the closer it comes to reflecting or representing the real phenomena. Due to the relative number of responses from small and large sized organisations, three classes of small organisations and two classes of large organisations were created, hence a total of five groups. The five groups of respondents were:

. Organisations with one to twenty employees [1 - 20]

. Organisations with twenty one to fifty employees [21 - 50]

. Organisations with fifty one to two hundred employees [51 - 200]

. Those with two hundred and one to one thousand employees [201 - 1000]

. Organisations with more than one thousand employees [> 1000]

The respondents were asked to name and rank the factors which they considered during the process of vendor selection. They were asked to rank them according to how importantly they regarded each factor. Ranks 1 to 20 were to be awarded. Any factor which was awarded rank 1 indicated the most important while rank 20 represented the least important. The ranking was intended to capture data about the factors which play more dominant role(s) to various organisations and those which do not (or are not considered at all) during the selection process. The quantitative analysis used Spearman's rank order correlation, Cohen [1982], to determine the level of correlation between the awarded ranks. A Kruskal-Wallis test, Anderson, Sweeney & Williams [1987] and Levin [1987] was performed to assess the degree of variation in the way which the organisations regarded the factors. The statistical techniques used are explained in more detail as they are used in chapter 5.

The second set of analysis was designed to ascertain how different types of organisations solved the vendor selection problems, and to determine whether the type of organisation affected the way it tackled the problem(s). Five types of organisations which completed and returned the questionnaire were classified as follows:

Engineering

Process

Textiles

Printing and Packaging

Services.

Again, this set of analyses employed the features of three of the research families, ie deskwork, quantitative and qualitative methodologies.

4.4.2. DEVELOPMENT PHASE

The development methods and methodologies used vary from one computer application to another. This is because different systems required a different approach and development tools.

4.4.2.1. PROGRAM DESIGN METHODOLOGY

This referred to the methodology used for the design of the prototype expert systems that was developed. The top-down approach was the methodology adopted for the program design. This approach started with the end user requirement (ie the goal) and then worked down to the input requirement. For instance, in our program, the end user requirement from the program was to determine whether a potential supplier(s) had good financial background. Good financial background therefore became the goal. Hence the input requirements were the knowledge which would enable the program to achieve that goal.

As a Rule-Base system, the way rules were organised within the system would affect when they would be processed and how easily the system would be read, maintained, modified or debugged. Pedersen (1989) suggested that the best way to structure the rules was to:

$. Organise the rules which conclude the same thing together

$. Place the most likely rules to use first

$. Organise the rules in the order of hierarchy (see figures 7.5 and 7.9)

This is explained further in chapter seven of the thesis.

The development method used was what Turban (1990) referred to as Rapid Prototyping. He defined prototype in expert systems as a small scale system which represents the acquired knowledge in a manner that enables quick inference to be made about certain domain issues. As a preliminary to the intended program, a prototype would help the system builder to grasp the qualities of the expert system and to decide on the structure of the knowledge base before investing a large amount of effort in the full system. Among the advantages of prototyping are its abilities to:

. demonstrate the capabilities of expert systems,

. provide an indication of acceptability of an expert system,

. generate or increase awareness or interest in expert systems,

. provide an indication of costs of building the full system, etc.

A more general total systems development approach by McNurfin (1989) was studied in the process, and the knowledge acquired contributed immensely at this stage of the research. This approach would be re-visited during the development phase of the comprehensive Expert System which could be used for performing the entire vendor selection and evaluation function.

The approach consists of:

1.) Systems planning:- dealing with such issues as:

- identifying information and other needs for the system to active desired objective(s).
- determining how these needs should agree and fit together,
- providing estimate of time requirements to complete the system,

- establishing decision levels and priorities, etc,

2.) Project definition:- covering the various aspects of:

- the scope of the project,
- the project constraints,
- the background information and information requirements,
- work programme and project reporting proposals,
- etc

3.) Systems analysis:- addressing the issues concerning:

- survey of existing system to establish information needs as to what?, why?, how quickly?, by whom?, etc
- critical areas, delay phone areas, source data and sources of data,
- authorisationn of access toinformation, confidentiality and security, etc
- techniques for gathering data ie review of documents, interviews, observations, questionnaires, etc.

4.) Systems design:- taking into account:

- design specifications, ie describing in full detail each program, the layout, input and output format, interface between programs, control requirements,

  etc.

5.) Systems justification and selection:- taking into consideration:

- the economic, operational and technical implications,
- the selection of hard ware and soft ware components,
- the system personnel and training requirements.

6.) Systems implementation which is meant to be:

- finalise the design
- develop the programs
- train the users and the operators
- arrange for the relevant equipment
- test the system
- plan the systems delivery
- deliver the system

4.4.3. SYSTEMS TRIAL

The prototype system (ESfVS) was continuously tested throughout the development process by the developer. After the completion of the program, it was then taken to the intended users for a trial run to certify:

. whether the program would perform the desired function, and

. to further enhance the users' awareness of expert systems.

The trial was accompanied by the second set of the questionnaires. The use of this questionnaire was to capture: (see questionnaires in appendix 7)

. How the users would react to using the prototype

. The acceptability and the commercial viability of the program

. The extent to which the program contributed to an improvement in the knowledge of expert systems within organisations.

4.4.3.1. TEST PERSONNEL

The intended users of the expert system are the people in the purchasing and supply chain management who actually perform the vendor selection function. These are the purchasing managers or senior buyers. They were selected from organisations within the geographical areas of Lancashire and Yorkshire. Contacts with these professionals and their organisations were established during the process of the first questionnaires, and had been maintained throughout the development stages of the system.

The reason why the test personnel were chosen from the same geographical location was to minimise the costs of conducting the tests. This is because the researcher had to visit the test personnel individually in their various locations in order to conduct the test. The reason being that they would not have a User Licence for the software used to develop the ESfVS system (ie. Crystal Version 4). Hence, the researcher had to take his own personal computer system to each of the test sites.

Unlike the first questionnaire, where a postal survey was considered to be the most appropriate method, this second questionnaire was delivered by hand. This is because since the computer unit with the full Crystal version 4 program (ie. the system software) and the ESfVS was taken to these organisations for them to run the test, it was deemed appropriate to take the questionnaires along, and asked them to complete the forms at once. They were directed on how to use the system before they were asked to begin the test. After the tests, the second set of questionnaires was given to them to complete. The respondents were allowed as much time as they needed to fill the questionnaire forms. Explanations were provided for them whenever they asked questions. As a result of this method of administering the questionnaires, a 100% response rate was achieved.

It will, however, be appropriate at this stage to emphasize that the group of the intended users are small organisations which do not have the expertise enquire about the financial background of the potential suppliers in the way large organisations do. Therefore, the characteristics of the systems test personnel are that the tester must be the one who performs the vendor selection tasks, and must come from an organisation:

with between 1 and 20 employees, and

within the geographical locations of Lancashire and Yorkshire.

4.4.3.2. TEST PARAMETERS

The tests conducted by both the developer and the potential users included:

Typographical errors: this test was to ensure that attributes and their values were consistent wherever and whenever they were used in the program. This is because any mistake or inconsistency would cause the system to understand them as being different.

Rule Test: this test was designed to ensure there was no ambiguity in the rules, ambiguity in the sense that no rule should have more than one conclusion, and that the rules were not poorly structured. Syntax tests were also performed at every stage of the program development. The test went further to ensure that no rule "fell through". A rule is said to have fallen though if it does not match any condition of a consultation. This also happens when the inference engine cannot match the actual conditions of its knowledge sources to any rules, ie., after considering and exhausting all knowledge sources, it would then declare the goal unknown and terminate the consultation.

Content Testing was performed by both the designer and the intended users to check whether the results and conclusions were correct. Where calculations were required, the developer used an electronic calculator to work out the solution, and then compared the results with that of the system. Verification of the correctness of other qualitative results of the system was performed by comparing the answers from a human expert (ie. other purchasing professionals) in the domain of application.

Early User Tests were adopted in order to ensure that the advice or the results would be accepted, rather than developing a complete system, only to discover at the end that it would not be accepted. Hence, establishing that the system met the needs on usability was a prerequisite. This method was used in order in detect errors and flaws in time before errors became costly to rectify. Modifications or complete re-design at an early developmental stage of the system would not require as much effort as it would have done if the system had already been completed. Testing early and often helped to generate regular feedback and enabled focus on conformance of what was required of the system.

4.4.3.3. TEST DATA

The data used for testing the program was provided by three business organisations. The companies are: Stilmet International Ltd., Hardis & Dromedas Ltd. and The Universal Resource Management Ltd. These data are the company's yearly financial statements in the form of the Balance Sheets and the Profit & Loss accounts. It was from them that the values of Stock, Current Assets, Current Liabilities, Gearing, etc. which were used for the analysis and system testing were derived.

The systems trial, as one can deduce from the activities involved, drew primarily on three Research Approaches; it took the form of an Experiment and also involved Case Studies and a Survey. It also employed the features of three Research Families in the form of Fieldwork, Qualitative and Quantitative models.

5. ORGANISATIONAL APPROACH TO THE PROBLEM OF VENDOR SELECTION

In order to find out how organisations tackle the problem(s) of vendor selection, some form of contact with the organisations would have to be made. At this point, the issues of:

. which organisations and

. how many organisations

to approach needed to be resolved. Ryan et al (1992) stressed that, as there was no formal requirement, for instance for the number of observations, a large number of observations is important. They suggested that at least fifty observations are necessary to give an indication of a certain performance model. Blalock et al (1968) believed that one hundred samples or observations of a phenomenon were needed to reflect its true picture. For this reason, a target of at least fifty companies was sought. The characteristics of the target companies were:

. each of the companies must be a manufacturing concern, and

. each must be based in England.

Nwagboso (1997) hinted that a postal survey researcher should expect about an 8.5% return rate, although that would be dependent on a variety of factors, such as the nature of the research, the sample population, etc. In this case a 10% response rate was the target. Therefore, in order to receive fifty reponses Ryan et al (1992) at the 10% response rate, five hundred organisations had to be approached. The knowledge about the way in which fifty or more organisations solve a particular problem was expected to provide an indication on how that problem is generally dealt with.

The method used was to design a survey questionnaire and send it to them by post. Analysis of the questionnaire method of data collection was discussed in the previous chapter. A copy of the survey questionnaire and a covering letter are included in the appendix 1. A stamped, self addressed envelope was included in the mailing package in order to encourage the respondents to return the completed questionnaires. The objectives at this stage were to:-

- make contact with people in the industries who may be involved in the later stage of the research programme,
- ascertain the general idea of how companies look at the problem of vendor selection,
- find out if there is any form of commonality in the way that the vendor selection problem is solved,

. assess the awareness of expert systems technologies within the purchasing organisation,

. generate more awareness and interests in expert systems and its capabilities,

. ascertain whether those in the purchasing and supply function will be prepared to use the technology, if developed to solve vendor selection problems .

Out of the five hundred questionnaires sent to these organisations, sixty six (66) were completed and returned. Thus, giving a response rate of 13.2%, comparing favourably with the target 10%.

5.1. THE RESPONSE CLASSIFICATIONS

The completed and returned questionnaires were organised and analysed. In the first place, they were organised into two classes. These are :

. The size of the respondent organisation and

. The type of the respondent organisation.

This is because the respondent organisations are of different sizes and come from various types of industries. Therefore, the analyses of the replies were performed based on this background, as explained in section 4.4.1.4.

5.1.1. THE SIZE CLASSIFICATION:

The completed and returned questionnaires were divided into five groups according to the size of the organisation. In this case, size is determined by the number of employees in each organisation. The five groups are:-

(1). Organisations with between 1 & 20 employees (1 - 20)

(2). Organisations with between 21 & 50 employees (21 - 50)

(3). Organisations with between 51 & 200 employees (51 - 200)

(4). Organisations with between 201 & 1000 employees (201 - 1000)

(5). Organisations with more than 1000 employees. (> 1000).

The number of responses in each group was calculated as a percentage of the total responses. 27% of the responses came from organisations which employed between one and twenty people. 24% came from organisations with between twenty one and fifty employees, whereas organisations which had between fifty one and two hundred employees contributed 23% of the total responses. 18% of the sixty six respondents are organisations which employed between two hundred and one and one thousand people, while the remaining 8% replies cames from companies with more than one thousand employees. Table 5.1 overleaf shows the percentage response from each of the five groups of the respondents.

Table 5.1. Percentage response from each group in size classification.

GROUP	No. OF EMPLOYEES	% RESPONSE
A	1 - 20	27
B	21 - 50	24
C	51 - 200	23
D	201 - 1000	18
E	> 1000	8

5.1.2. THE TYPE CLASSIFICATION

The second classification was based on the type of organisation. All the sixty six completed and returned questionnaires were again divided into five groups, according to their type. The five groups are:

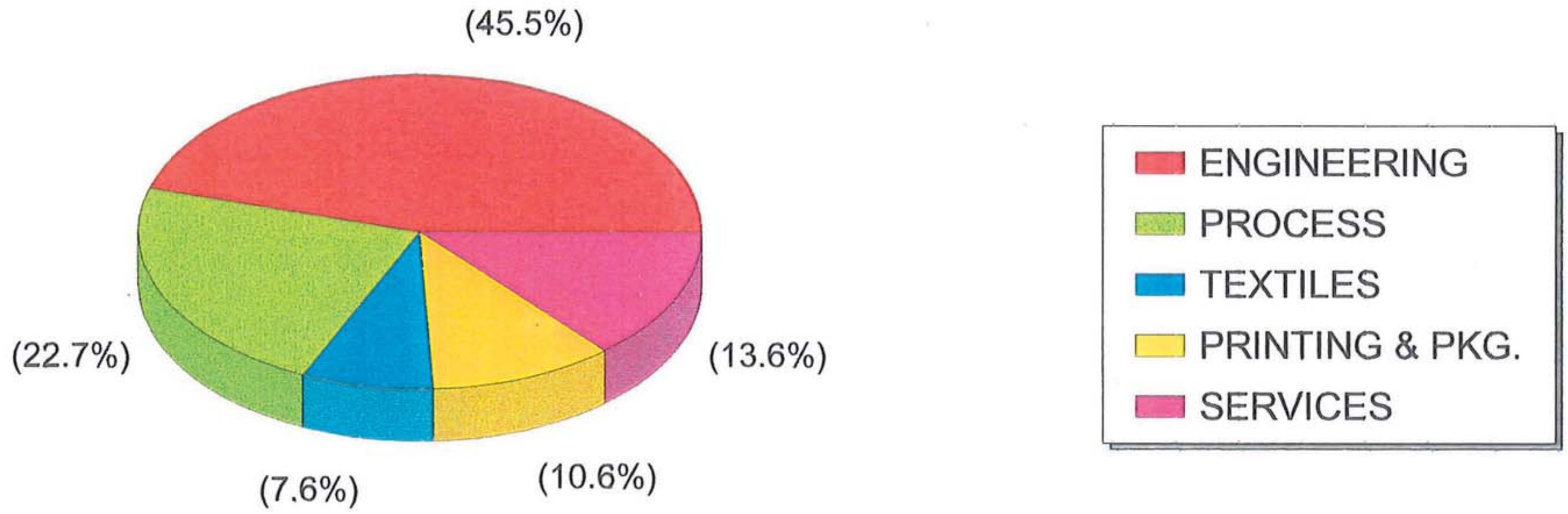
(1). Engineering, (2). Process, (3). Printing & Packaging
(4). Textiles and (5). Services.

Out of the sixty six responses, 45.5% of them came from engineering companies, 22.7% from process industries, 7.6% from textiles, 10.6% came from Printing & packaging while the remaining 13.6% came from the services industries. These percentage responses are shown in Figure 5.1.

See the pie chart overleaf, in page 112.

Figure 5.1

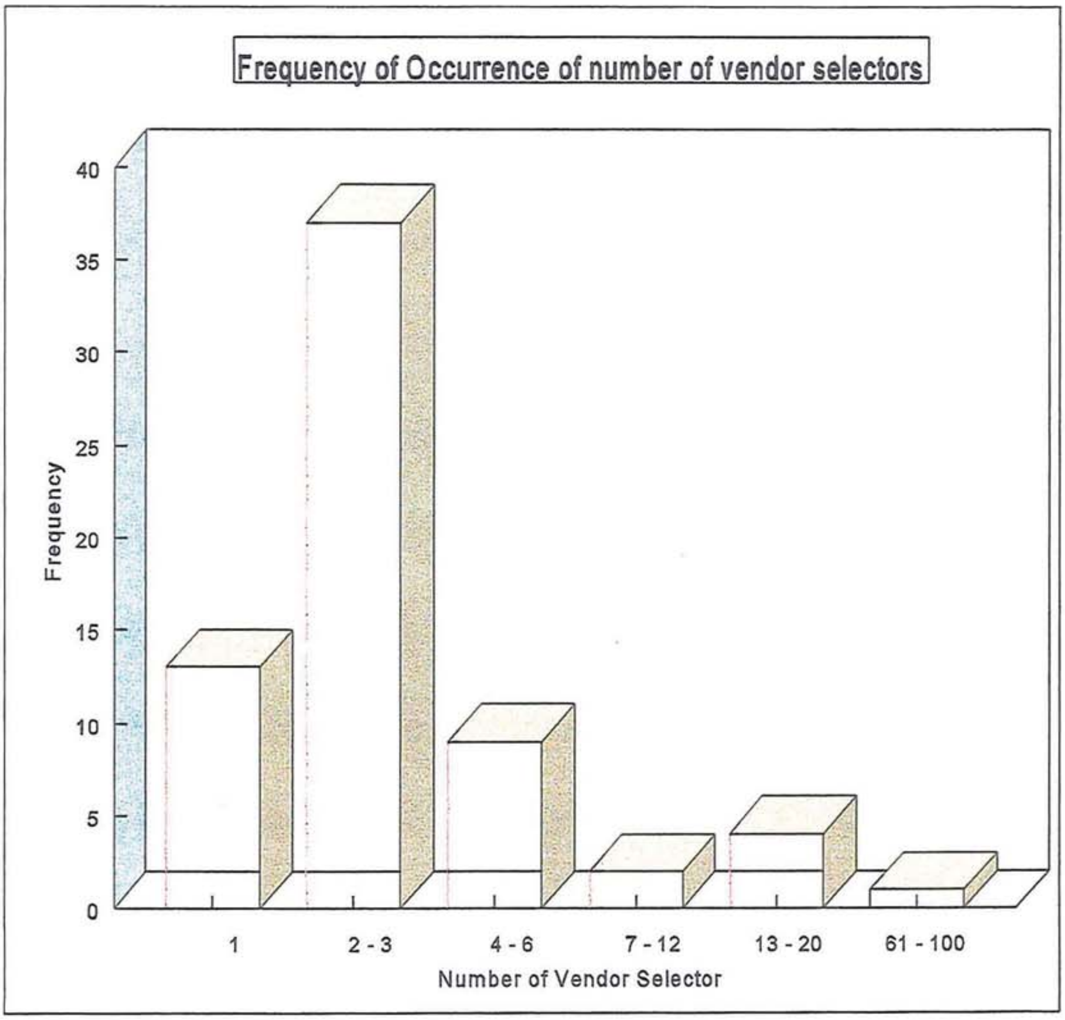
Number of Response from each type of Organisation as a % of total Responses.



5.1.3. ANALYSIS OF EMPLOYEES

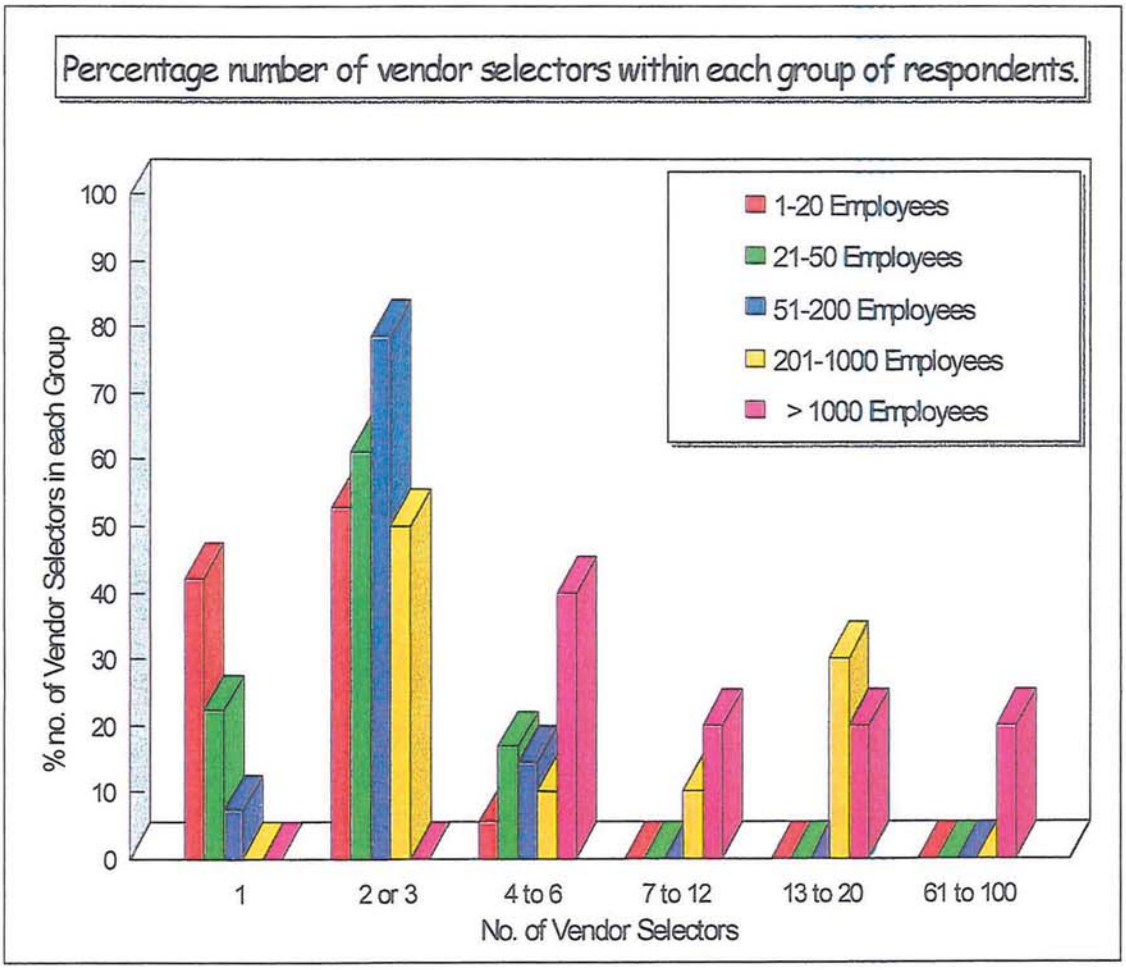
The answer to Question No.2 suggested that more than fifty percent of the respondents have two or three people in their organisations who actually perform the vendor selection tasks. Exactly 13 respondents said they have only one employee who deals with the problem of vendor selection. One respondent claimed to have between 60 and 100 employees who perform the task. Further investigation revealed that that company has more than ten thousand employees in total. The bar chart, figure 5.2, below shows the frequency of the number of vendor selectors employed by the respondents.

Figure 5.2.



In fact, that company was one of only five organisations who employed more than one thousand people. Forty percent of this group (ie. organisations with more 1000 employees) have between 4 and 6 people who actually perform the vendor selection tasks, while 20% have between 7 and 12 employees who deal with the problem. In the group with 51 to 200 employees, 7.14% employed only one vendor selector, 78.57% of them employed 2 or 3 vendor selectors, while the remaining 14.29% employed 4 to 6 people to deal with the problem. Figure 5.3 shows the percentage number of vendor selectors within each group of respondents.

Figure 5.3



5.2. THE RANKED FACTORS

After the literature review and discussions with those in the purchasing and supply function who are responsible for vendor selection, it was established that the following twenty factors are considered during the vendor selection process. These factors are:

1. Product price; which details the price, additional discount or cost, payment arrangement, etc
2. Product Quality; stating the size, type, shape, etc
3. Delivery Date; disclosing the lead time, due date, etc
4. Production Method; detailing types of method(s) used, eg 'push or pull', etc
5. Financial Background; which assesses a company's financially stability, etc
6. Manufacturing Capacity; which measures the plant's facilities, flexibilities, etc
7. Management Efficiency
8. Technical Competence
9. Similarity in Technology used
10. Size of the Organisation
11. Geographical Location
12. Position in the Industry

13. Conduct of the Sales Representatives

14. Honesty

15. After Sales / Backup Services

16. Recommendations from Associates or Friends

17. Loyalty to Friends or Relatives

18. Ability to Provide Sufficient Information about the product

19. Whether the company is listed in Business Directories

20. Company's Interest in your Product(s).

These factor names were abbreviated for more convenient reference. They and their abbreviations are listed in table 5.2 overleaf.

Table 5.2. The Ranked Factors and their abbreviations.

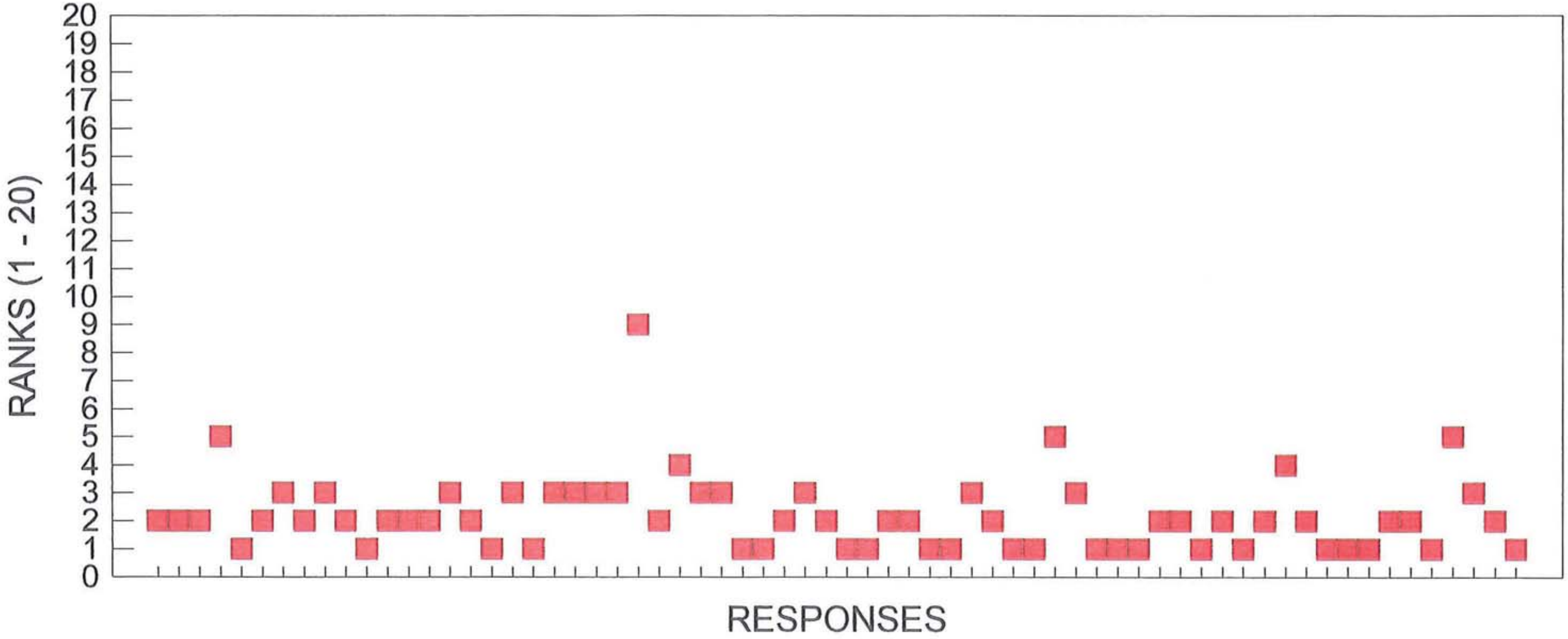
Ranked Factors:	Abbreviations:
Product Price	PRIZ
Product Quality	QLTY
Delivery Dates	DDTE
Production Method	MTOD
Financial Background	FNCE
Manufacturing Capacity	CPST
Management Efficiency	MGTE
Technical Competence	TKCE
Similarity in Technology used	SMTK
Size of the Organisation	SIZE
Geographical Location	GOLK
Position in the Industry	PIND
Conduct of the Sales Reps	REPS
Honesty	HNST
After Sales/Backup Services	BKUP
Recommendations from Associates or Friends	RCMN
Loyalty to Friends or Relatives	LYTY
Ability to provide Sufficient Information	INFO
Listed in Business Directories	LSTD
Their Interest in your Product(s)	INTR

5.2.1 THE RANKS

Question number three in the survey questionnaire required the respondents to name the factors which they considered during the selection process, and to rank them according to how importantly they regard the factors. The ranks from one to twenty (1 - 20) were to be awarded according to the order of importance in which the particular organisation deemed appropriate. The factor which was ranked one meant it was considered the most important. Rank two meant the second most important, etc., and any factor that was given the rank twenty (20) meant the least important. The factors which were not ranked at all were also treated as being of least importance, and therefore awarded rank 20. The ranks awarded to each of the twenty factors by the respondents were recorded and then transformed into scatter diagrams. For example, the Product Price (PRIZ) is shown in figure 5.4 overleaf. The full display of the ranks as awarded for the twenty factors is presented in the form of a scatter diagram shown in appendix 1B.

Figure 5.4.

RANKS FOR THE PRIZ VARIABLE



As mentioned earlier, the factor which is ranked 1 is considered to be the most important, rank 2 indicated the second most important, etc until rank 20 which represented the least important (or factors which were not ranked at all). However, where two or more factors were considered to be of equal importance and thus awarded the same rank, then:

. the next in rank will not have the next immediate rank. For instance, if the factors; Price(PRIZ) and Quality(QLTY) are both given the rank 1 then the next immediate factor will have rank 3 instead of 2.,

and

. the average of the ranks were calculated and awarded to these factors. For instance, if the factors: Financial Background (FNCE) and Honesty (HNST) were both awarded 1, then they would both have the rank of 1.5, ie ((1+2)/2)) instead of the rank 1.

The average of the ranks awarded to each factor was calculated. These averages are presented in the form of a bar chart in figure 5.5 in page 121 overleaf. These averages were compiled and the factor which has the least ranked value was regarded as the most important. Table 5.3 in page 122 shows the average ranks in order from the lowest to the highest, thus representing the position of each of the twenty factors.

Figure 5.5 AVERAGES OF THE AWARDED RANKS

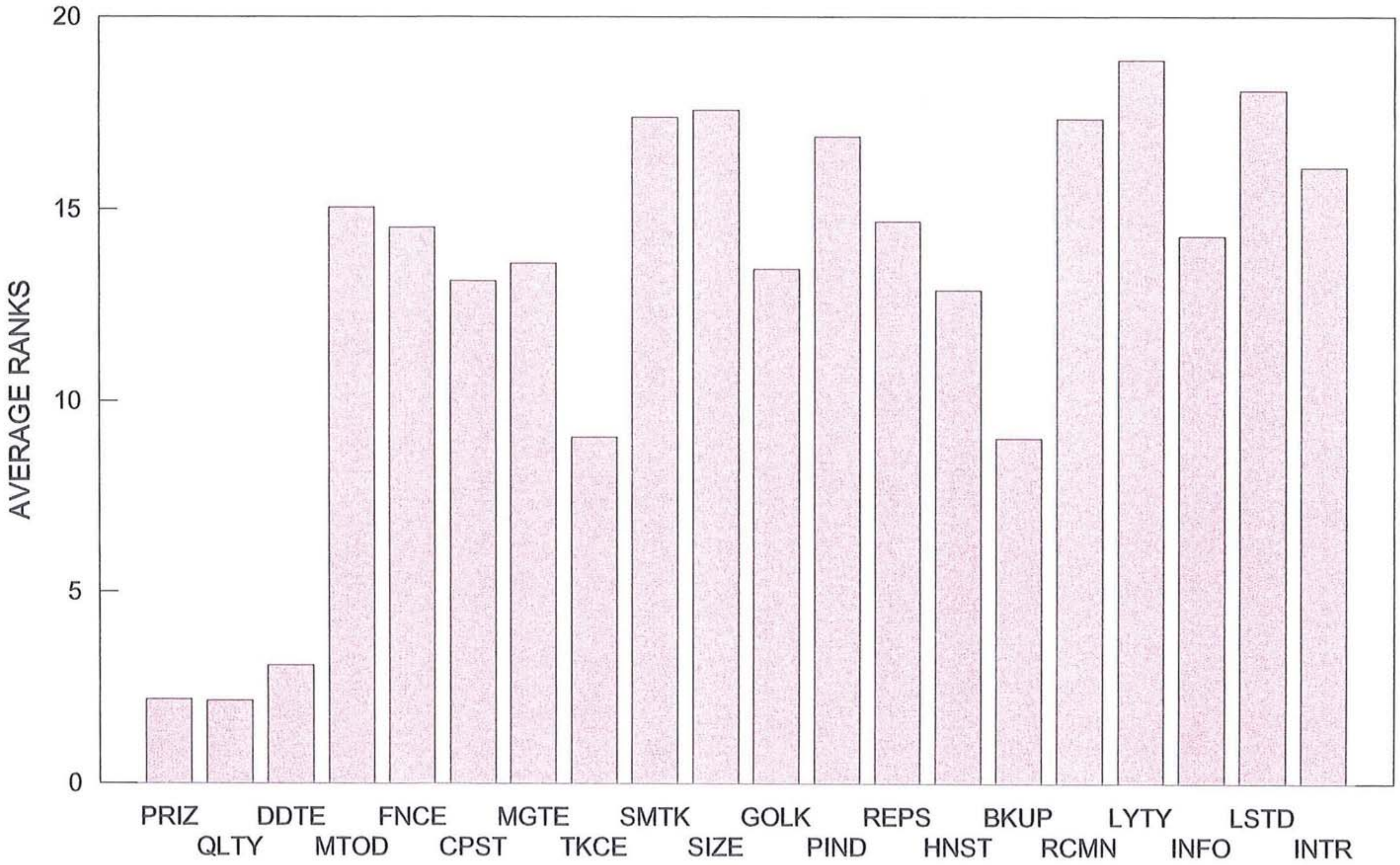


Table 5.3. The Average Ranks and the Positions of the Ranked Factors.

Factors:	Average Ranks:	Position of the factors:
QLTY	2.15	1
PRIZ	2.18	2
DDTE	3.08	3
BKUP	9.03	4
TKCE	9.06	5
HNST	12.89	6
CPST	13.15	7
GOLK	13.45	8
MGTE	13.61	9
INFO	14.30	10
FNCE	14.53	11
REPS	14.68	12
MTOD	15.05	13
INTR	16.08	14
PIND	16.88	15
RCMN	17.35	16
SMTK	17.39	17
SIZE	17.58	18
LSTD	18.09	19
LYTY	18.88	20

Table 5.3 above shows the ranks awarded to the various factors and the position achieved by each of the factors. It shows that QLTY is regarded as the most important factor, PRIZ became the second most important, etc., until LYTY which is therefore regarded as the least important.

5.3. ANALYSIS BY SIZE

As mentioned earlier there are five groups of respondents namely, the organisations with:

. 1 to 20 Employees

. 21 to 50 Employees

. 51 to 200 Employees

. 201 to 1000 Employees and

. more than 1000 Employees.

The ranks awarded by these five groups are included in the appendix 2.

5.3.1. AVERAGING THE RANKS

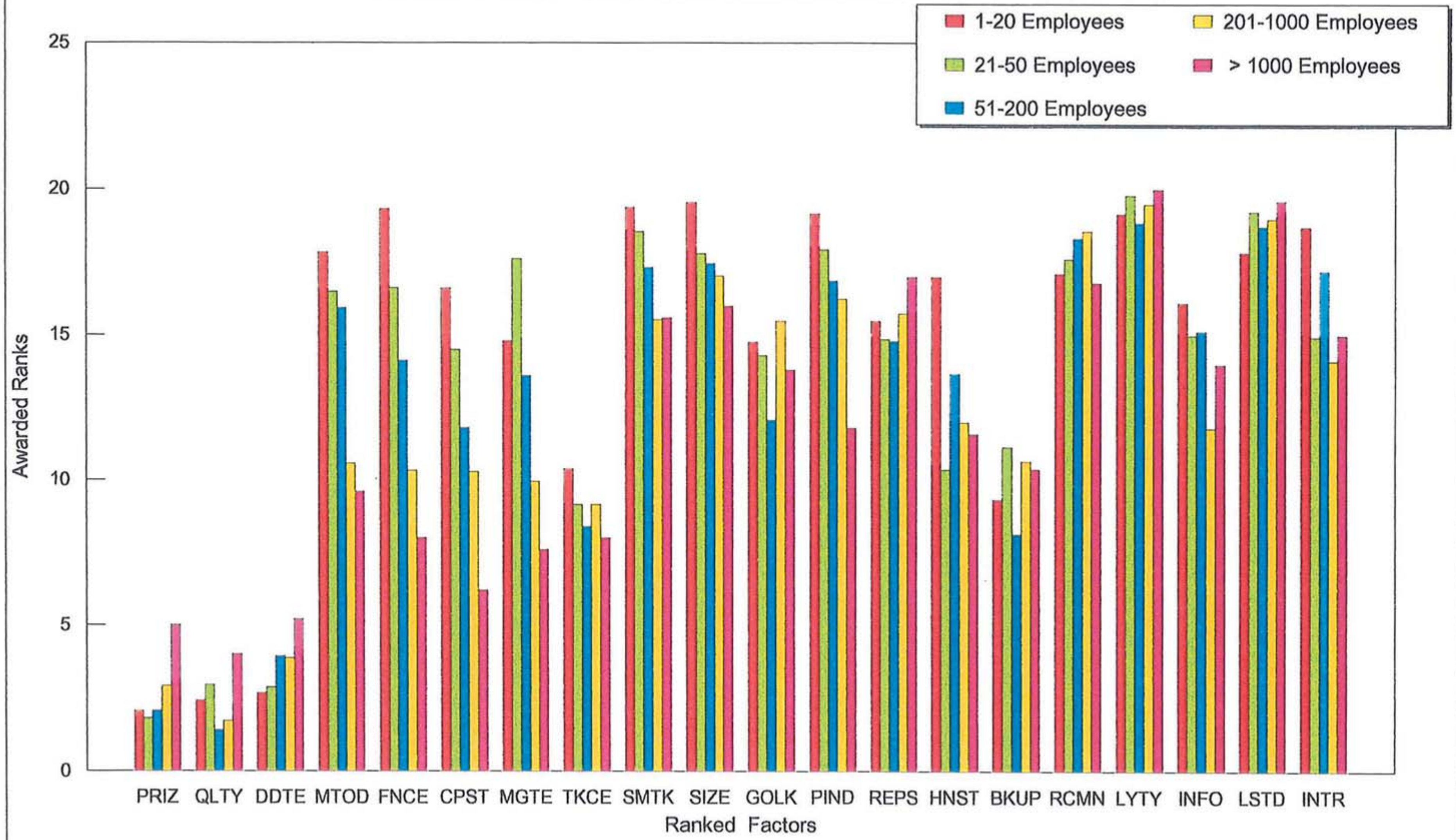
The ranks were compiled, and the average ranks from the five groups of the respondents were calculated. The achieved results were organised and presented in table 5.4 overleaf. The average ranks were then transformed into a bar chart of figure 5.6. Various patterns emerged as may be seen in page 125. Especially interesting patterns were observed for the following factors: MTOD, FNCE, CPST, SIZE and PIND. For these factors, the results appeared to suggest that the larger the organisation, the better the average rank given to them. The table of the average ranks is shown in page 124, and the bar chart in page 125 illustrates these patterns.

Table 5.4 Average of the Ranks awarded by the various groups of respondents.

FACTORS	NUMBER OF EMPLOYEES IN EACH GROUP				
	1- 20	21 - 50	51 - 200	201 - 1000	>1000
PRIZ	2.06	1.81	2.07	2.92	5.00
QLTY	2.42	2.94	1.40	1.71	4.00
DDTE	2.67	2.88	3.93	3.88	5.20
MTOD	17.83	16.50	15.93	10.58	9.60
FNCE	19.33	16.63	14.13	10.33	8.00
CPST	16.61	14.50	11.80	10.29	6.20
MGTE	14.81	17.63	13.60	9.96	7.60
TKCE	10.39	9.16	8.40	9.17	8.00
SMTK	19.39	18.56	17.33	15.54	15.60
SIZE	19.56	17.81	17.47	17.04	16.00
GOLK	14.78	14.31	12.07	15.50	13.80
PIND	19.17	17.94	16.87	16.25	11.80
REPS	15.50	14.88	14.80	15.75	17.00
HNST	17.00	10.38	13.67	12.00	11.60
BKUP	9.33	11.16	8.13	10.67	10.40
RCMN	17.11	17.63	18.33	18.58	16.80
LYTY	19.17	19.81	18.87	19.50	20.00
INFO	16.11	15.00	15.13	11.79	14.00
LSTD	17.83	19.25	18.73	19.00	19.60
INTR	18.72	14.94	17.20	14.13	15.00

See figure 5.6 overleaf.

Figure 5.6 Average Ranks Awarded by the five groups of Size Category



5.3.2 CORRELATIONS & DIFFERENCES BETWEEN RANKS

A quantitative technique was employed to ascertain if any correlation existed between the ranks awarded by the five groups of the respondents. This was measured using Spearman's Rank Order Correlation Coefficient (Rs),

$$\text{where } Rs = 1 - \frac{6\Sigma d^2}{n(n-1)(n+1)} \qquad \text{-------(01)}$$

where:

Rs = coefficient of rank correlation

n = number of observations

d = difference between the ranks for each observation.

The average ranks in table 5.4 were themselves ranked to determine the relative rankings of the factors within each group. The positions of the average ranks are represented in table 5.5 overleaf. The Spearman's Rank Order Correlation Coefficient was then calculated in order to determine whether there was any correlation in the way these groups of respondents ranked the factors. The results are shown in table 5.6. Table 5.7 is the interpretation of the achieved results in table 5.6.

Table 5.5. The Position of the average Ranks.

FACTORS	1 - 20	21 - 50	51 - 200	201 - 1000	> 1000
PRIZ	1	1	2	2	2
QLTY	2	3	1	1	1
DDTE	3	2	3	3	3
MTOD	13.5	12	13	8	8
FNCE	18	13	10	7	6.5
CPST	10	8	6	6	4
MGTE	7	14.5	8	5	5
TKCE	5	4	5	4	6.5
SMTK	19	18	16	14	15
SIZE	20	16	17	17	16
GOLK	6	7	7	13	12
PIND	16.5	17	14	16	11
REPS	8	9	11	15	18
HNST	11	5	9	11	10
BKUP	4	6	4	9	9
RCMN	12	14.5	18	18	17
LYTY	16.5	20	20	20	20
INFO	9	11	12	10	13
LSTD	13.5	19	19	19	19
INTR	15	10	15	12	14

Table 5.6. The correlation between the ranks in organisations of different sizes.

Number of Employees	21 - 50	51 - 200	201 - 1000	> 1000
1 - 20	0.829	0.843	0.684	0.612
21 - 50		0.895	0.771	0.708
51 - 200			0.892	0.875
201 - 1000				0.954

The figures in table 5.6 suggested that there was generally a high correlation in ranks awarded by these sizes of organisations. The full interpretation of the results is illustrated in table 5.7 below. Since there was at least a high correlation between all adjacent size categories, it was concluded that different sizes of organisations appeared to agree on the order of the ranks awarded, although the agreement decreases the further apart the organisations are in size.

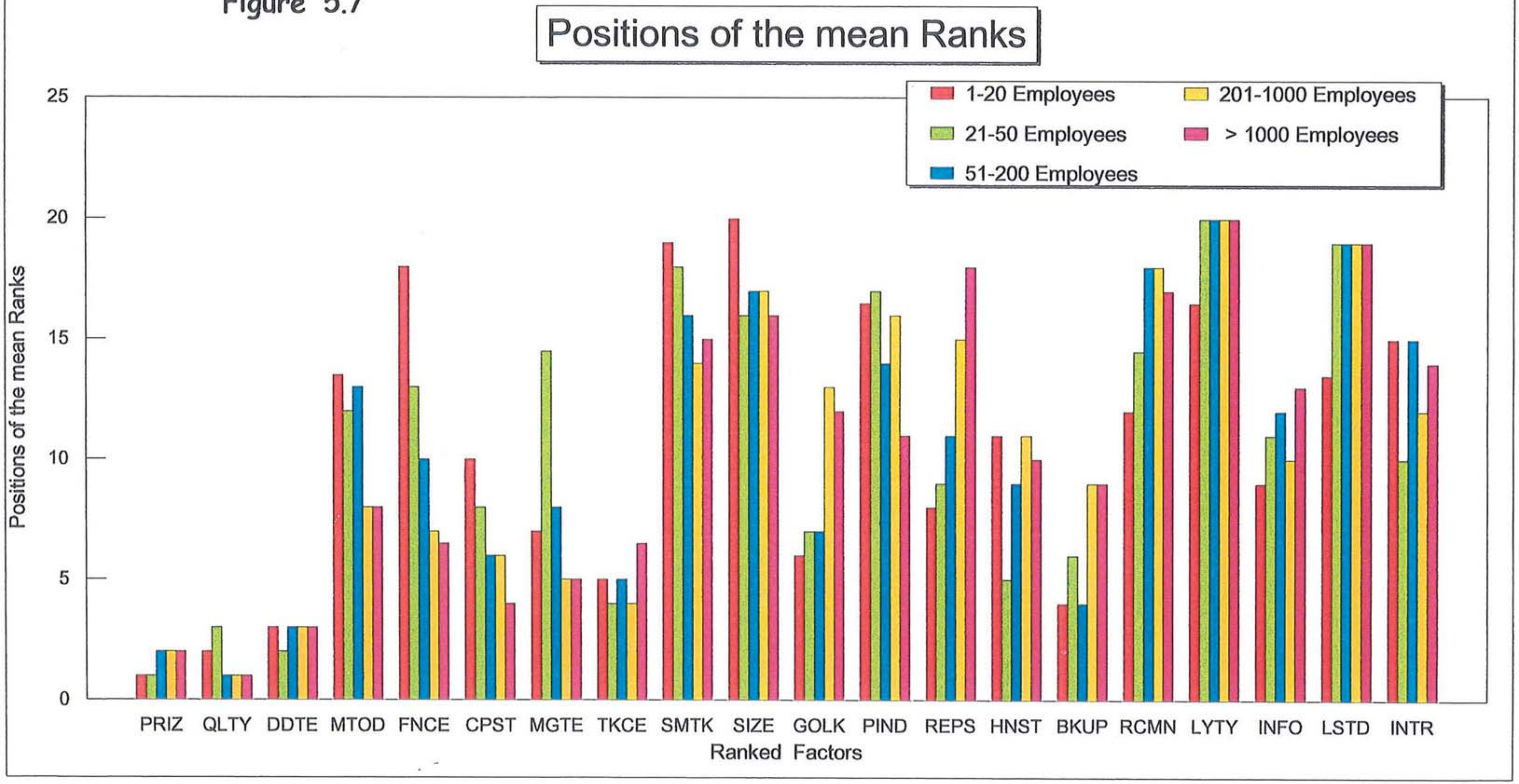
Table 5.7. Meaning of the results represented in table 5.6.

Correlation(Rs)	Interpretation of result
0.00 to 0.19	a very low correlation
0.20 to 0.39	a low correlation
0.40 to 0.69	a modest correlation
0.70 to 0.89	a high correlation
0.90 to 1.00	a very high correlation

Source: Cohen L. and Holliday M. [1982] page 93.

When the positions of the average ranks were transformed into a bar chart, another set of patterns appeared. In this case, FNCE and CPST appeared similar to the ones in figure 5.6 whereas the the factor REPS appeared in a reverse pattern order, suggesting that larger organisations believe this factor to be of less importance. See figure 5.7 in page 129 overleaf.

Figure 5.7



Positions of the mean Ranks
1-20 Employees
201-1000 Employees
21-50 Employees
> 1000 Employees
51-200 Employees
25
20
15
10
5
0
Positions of the mean Ranks
PRIZ QLTY DDTE MTOD FNCE CPST MGTE TKCE SMTK SIZE GOLK PIND REPS HNST BKUP RCMN LYTY INFO LSTD INTR
Ranked Factors

Further statistical tests were performed to establish whether any significant differences existed in the way each individual factor was ranked by the different groups.

Using the Kruskal Wallis one way analysis of variance by ranks, H is the statistic and is given by the formula:

$$H = \frac{12k}{N(N+1)} - 3(N+1) \qquad \text{---------------} \quad (02)$$

where:

N = the number of cases in all the samples combined

k = the total of the squared sum of the ranks in each of the samples divided by the respective number of cases in each of those samples.

The value of H was calculated for all the factors. Those for Financial Background (FNCE), Manufacturing Capacity (CPST) and Conduct of their Sales Reps (REPS) are shownin Table 5.8 below..

Table 5.8 Kruskal-Wallis Test of the differences in the awarded ranks.

TESTED PARAMETERS	H VALUES
Financial Background (FNCE)	25.40
Manufacturing Capacity (CPST)	16.56
Conduct of Sales Reps (REPS)	0.497

The value at 95% confidence level (ie $\alpha = 0.05$) is = 9.488. This demonstrated that there was a significant difference in the ranks by different sizes of organisation for FNCE and CPST. The ranks awarded varied depending on the size of the organisations, larger organisations ranking the factors as more important. The most significant was the way the ranks for the Financial Background of the potential suppliers were awarded.

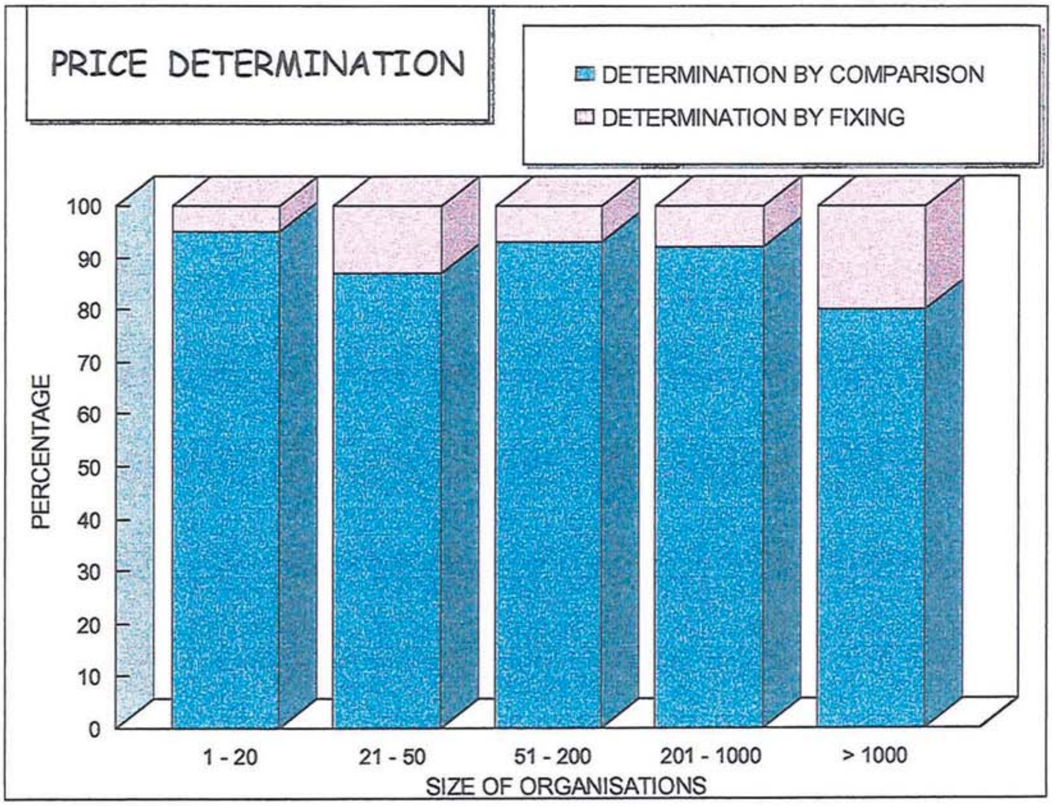
5.3.3. PRICE AND QUALITY DETERMINATION

The respondents were asked to disclose how they determine the price which they consider to be suitable. They were provided with two choices, namely:

.by comparing prices from different suppliers and then choosing the lowest price, or .by fixing the price that would suit their program.

Their replies were organised and translated into percentages which are represented in figure 5.8 below. The result suggests that almost all of them compare different prices before making a final decision.

Figure 5.8.



Twenty percent of big organisations (ie. those with more than one thousand employees) disclosed that they fix the prices which would be suitable for their course and then persuade their suppliers to meet that target. Unlike 95% of the small companies (ie. those with 1 - 20 employees) which would just compare prices from different suppliers and then settle for the lowest. See figure 5.8 in page 131.

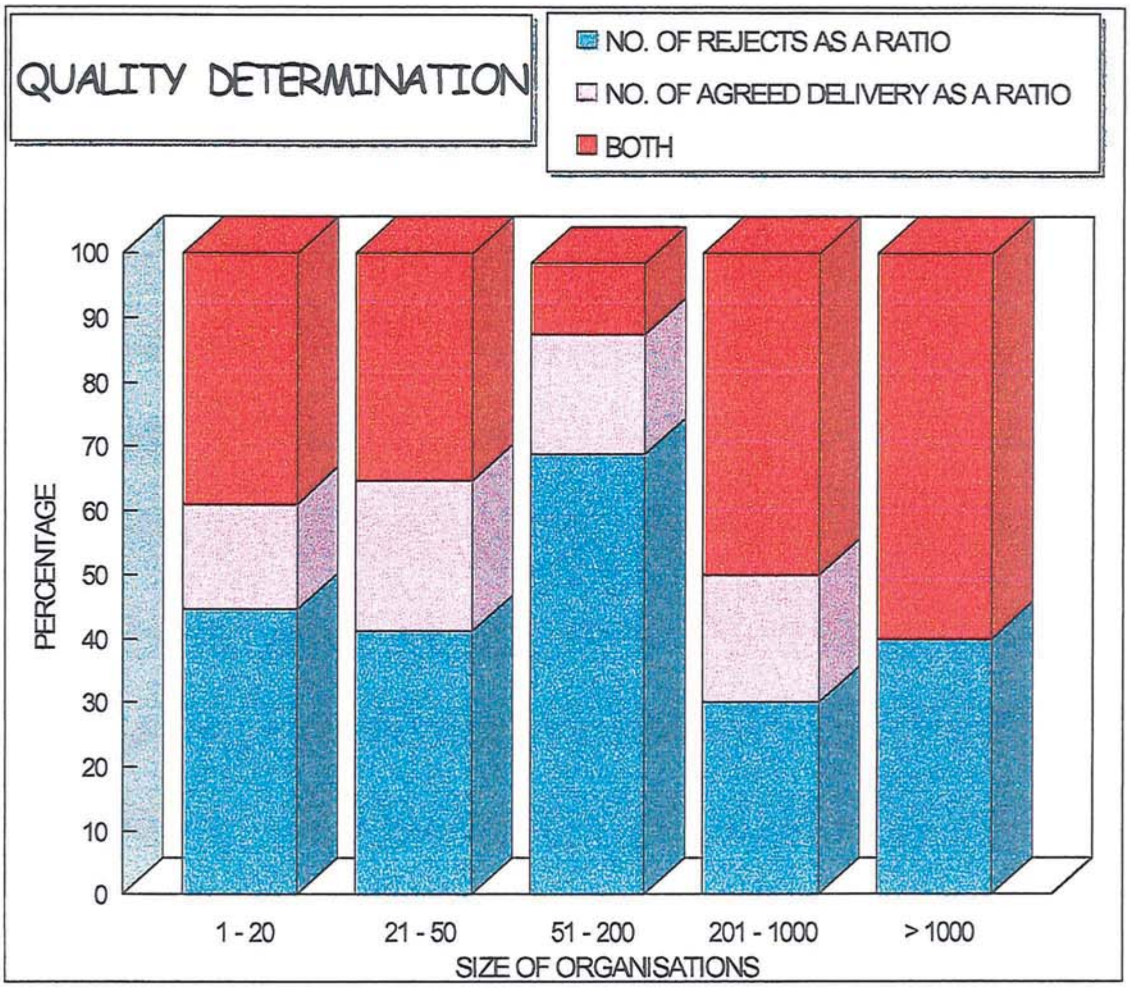
The respondents were also asked how they measure the quality of the suppliers' services. Two options were provided by the questionnaire. These were whether they use:

. the number of rejects (or defective items) as a ratio of the total delivery, or

. the number of the items which are delivered as and when agreed as a ratio of the total requisition.

Their replies were also organised and analysed. The responses in this case were different from the ones for price determination in figure 5.8. This is because many organisations use both methods for measuring the quality of their suppliers' services. Hence three possible answers were recorded. These responses were also organised and translated into percentages. The results are presented in figure 5.9 overleaf.

Figure 5.9

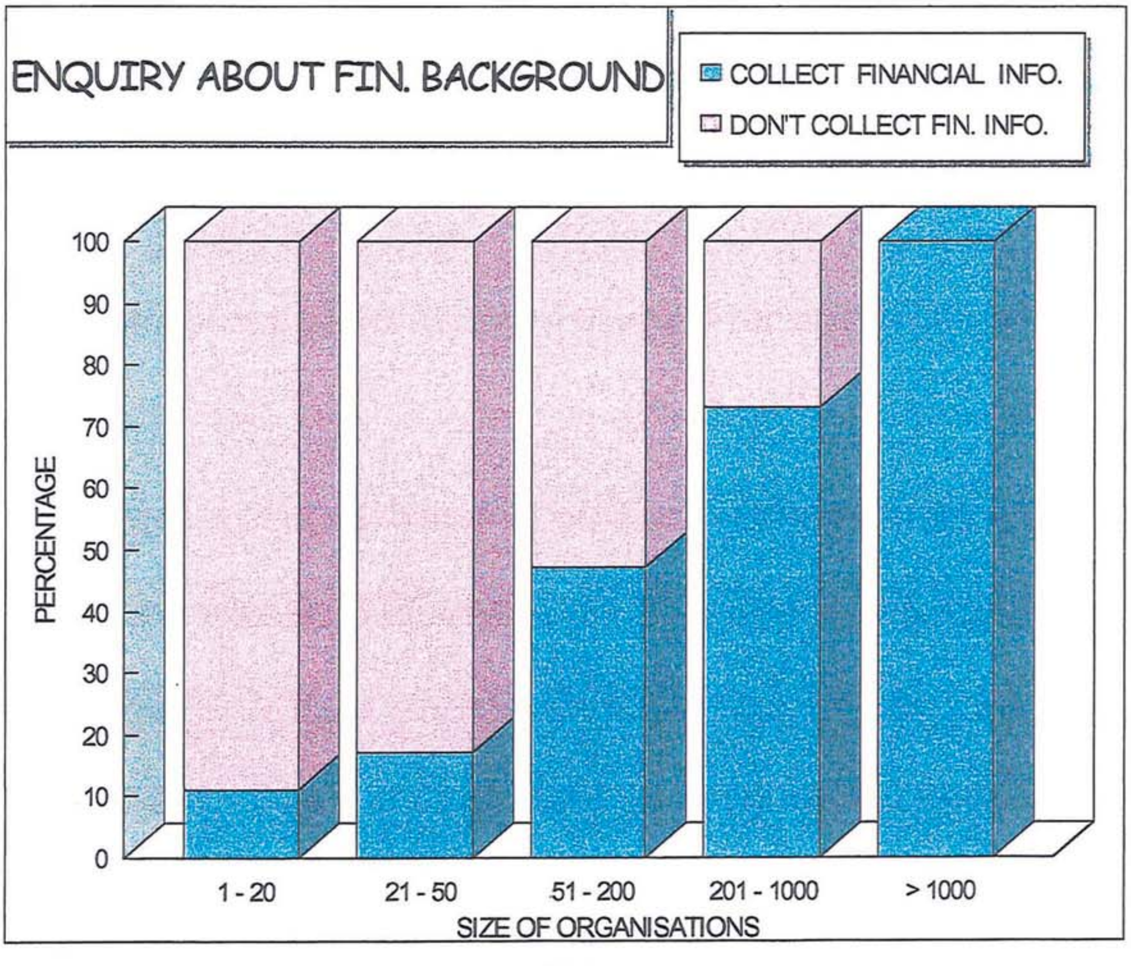


The above results indicate that the largest sized organisations employ both options more than the smaller sized respondents. It is peculiar to notice that the organisations with between 51 and 200 employees use the number of rejects as a means of determining quality service more than any other group. See figure 5.9. The figure also shows that organisations with more than 1000 employees do not use option two at all (ie number of agreed items delivered). They either use option one or a combination of option one and two together, not option two on its own.

5.3.4. FINANCIAL INFORMATION

The respondents were asked whether they inquire about the financial background of their suppliers. Their answers disclosed that most small organisations do not, whereas all the largest companies (ie those with more than 1000 employees) do. Figure 5.10 below shows the percentage of organisations within each group which collects such information about their suppliers. It is apparent that the larger the organisation the more the tendency to collect the financial information. This is consistent with the ranking of the importance of the finance factor (FNCE), as discussed in section 5.3.2.

Figure 5.10.



Those who do collect financial information disclosed their sources as:

. Companies House

. Dunn & Bradstreet

. Infotech Servives Ltd.

. Infocheck

. Banks

. Compass

. Financial Times

. Direct from the Suppliers.

5.3.5. AWARENESS OF E. S. IN ORGANISATIONS

None of the 66 purchasing departments which responded used expert systems technologies in performing vendor selection tasks. When asked, in question 9, why they did not use expert systems, the most common answer was lack of knowledge of the subject. They have little or no knowledge of Expert Systems and its capabilities. The level of awareness of expert systems within the five groups of the respondents is represented in table 5.9 overleaf.

Table 5.9 Awareness of Expert Systems in organisations.

NUMBER OF EMPLOYEES:	LEVEL OF AWARENESS OF ES:
1 - 20	15.8%
21 - 50	29.4%
51 - 200	40.0%
201 - 1000	16.7%
> 1000	20.0%

5.3.6. WILLINGNESS TO USE EXPERT SYSTEMS

In spite of the lack of knowledge of the technology indicated, some respondents said they would be willing to use an expert systems program if it were developed. Table 5.10 represents the level of willingness by organisations to use expert systems program to perform vendor selection tasks.

Table 5.10 Willingness by organisations to use E.S.program.

NUMBER OF EMPLOYEES:	LEVEL OF WILLINGNESS TO USE ES:
1 - 20	10.5%
21 - 50	42.2%
51 - 200	6.7%
201 - 1000	25.0%
> 1000	20.0%

A revelation is that those who were the most aware group of expert systems happened to be the least willing group to use it. The organisations with 51 - 200 employees were more aware of the expert systems capabilities than any other size group. Yet, they were the least enthusiastic about using the program in solving vendor selection problem(s). Organisations with between 21 and 50 employees were the most eager to use an expert systems program if it was developed, and they also had a relatively high percentage awareness of the subject. Figure 5.11 compares E.S. awareness and the willingness by respondents in various size organisations to use an expert systems program to help tackle the problem of vendor selection if it was developed. See figure 5.11 in page 138.

Many respondents admitted that they would need more information before they could make up their mind as to whether they would use the technology or not. Those who were willing to use the system believed that it would:-

. give a more balanced selection, taking into account various factors,

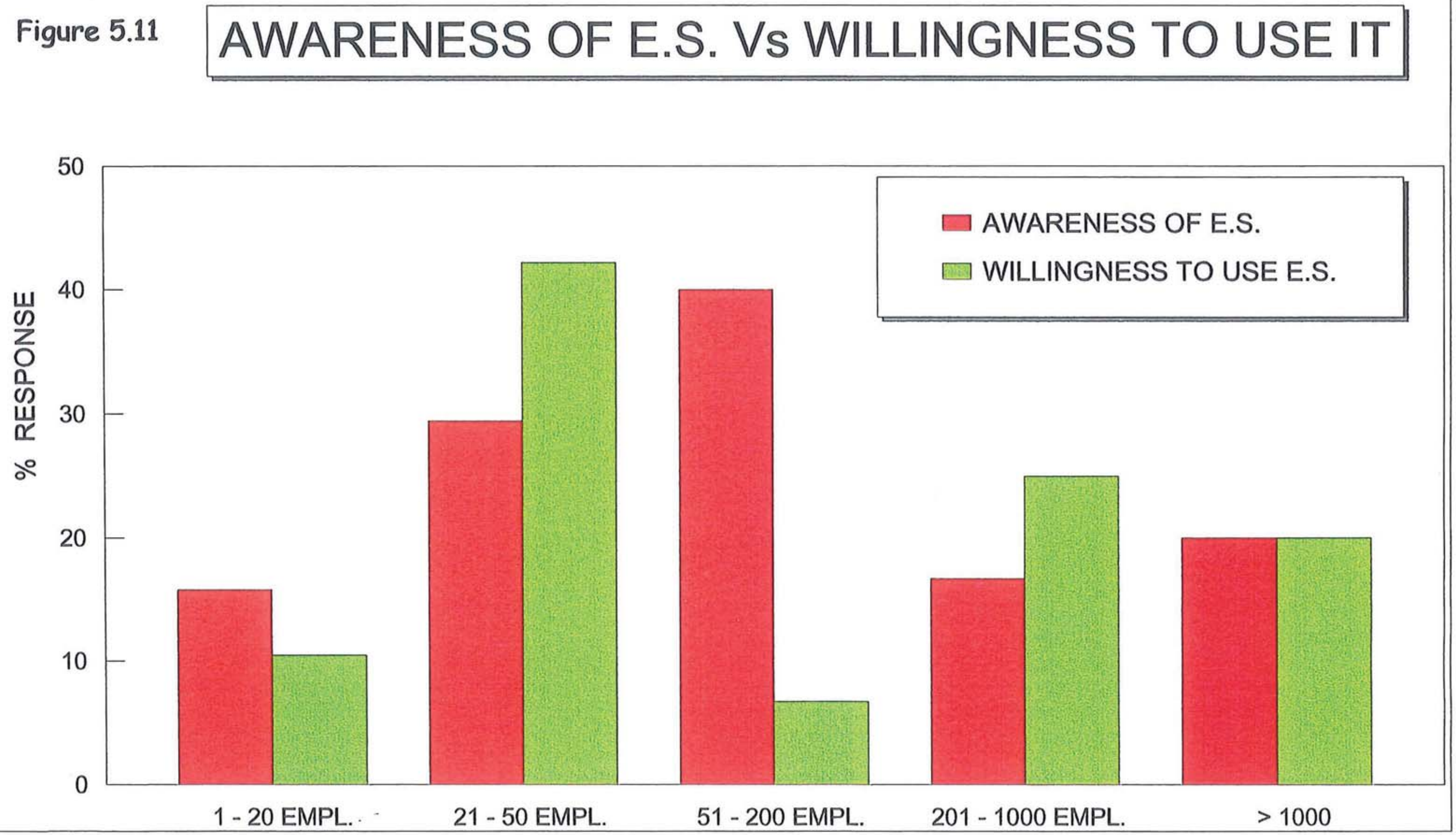
. discover alternative competitive supplier(s) on a national (or global) scale rather than the use of only local suppliers,

. provide a wider choice of selection,

. provide time savings in sourcing,

. provide a simplified and easier means of selection,

Figure 5.11


AWARENESS OF E.S. Vs WILLINGNESS TO USE IT
% RESPONSE
50
40
30
20
10
0
AWARENESS OF E.S.
WILLINGNESS TO USE E.S.
1 - 20 EMPL.
21 - 50 EMPL.
51 - 200 EMPL.
201 - 1000 EMPL.
> 1000

. provide the ability to adopt flexible selection parameters,

. provide the means for monitoring the supplier base,

. provide the means for quicker recognition of competent suppliers,

. provide the means for identifying BSI related suppliers,

. achieve a more efficient running of the purchasing function_ an improved purchasing programme.

The most significant argument cited by respondents against the use of expert systems for vendor selection focuses on the programs' ability to undermine personal responsibilities and empowerment, as well as the damage it can inflict on personal contact and supplier relationships.

5.4. ANALYSIS BY TYPE

As mentioned earlier, the five types of the respondent organisations are:

Engineering

Process

Printing & Packaging

Textiles

Services.

The actual ranks awarded by these types of organisations are shown in appendix 2.

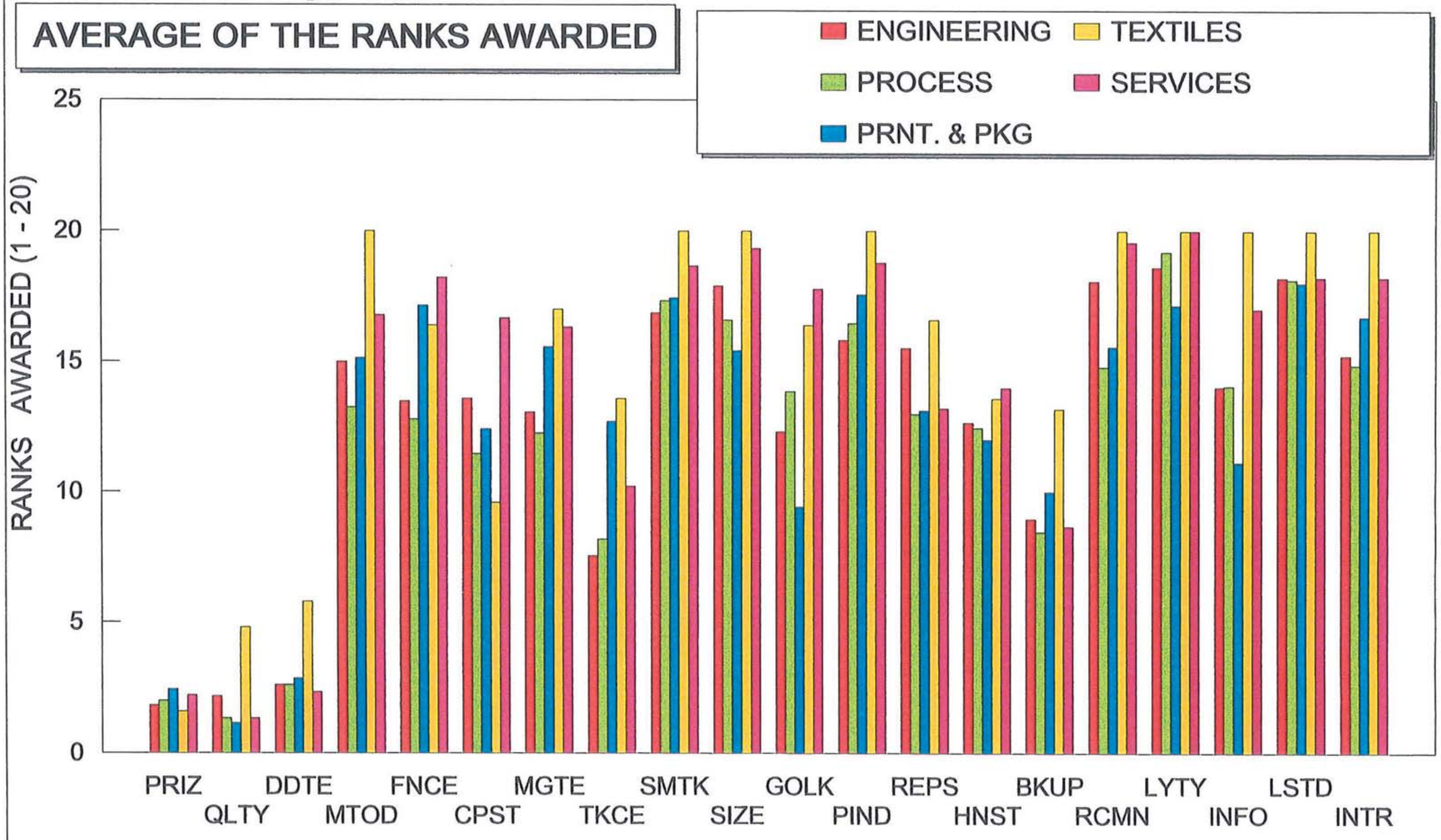
5.4.1. THE AVERAGE RANKS

The averages of these ranks were calculated and the derived results are presented in table 5.11. These averages were also trnsformed into a bar chart. Table 5.11 in page 141 shows the average as awarded by the various types of organisations while the figure 5.12 in page 142 is a bar chart of the information in table 5.11. Unlike in the case for Analysis by Size, there were no such patterns as those observed for the factors of; Financial Background (FNCE), Manufacturing Capacity (CPST), etc. These mean ranks were then organised in order to ascertain the actual positions of the factors.

Table 5.11

RANKED FACTORS	AVERAGE OF THE RANKS AWARDED BY THESE TYPES OF ORGANISATION				
	ENGINEERING	PROCESS	PRINTING & PKG.	TEXTILE	SERVICES
PRIZ	1.83	2	2.43	1.6	2.22
QLTY	2.17	1.33	1.14	4.8	1.33
DDTE	2.6	2.6	2.86	5.8	2.33
MTOD	15	13.27	15.14	20	16.78
FNCE	13.5	12.8	17.14	16.4	18.22
CPST	13.6	11.47	12.43	9.6	16.67
MGTE	13.07	12.27	15.57	17	16.33
TKCE	7.57	8.2	12.71	13.6	10.22
SMTK	16.87	17.33	17.43	20	18.67
SIZE	17.9	16.6	15.43	20	19.33
GOLK	12.33	13.87	9.43	16.4	17.78
PIND	15.83	16.47	17.57	20	18.78
REPS	15.53	13	13.14	16.6	13.22
HNST	12.67	12.47	12	13.6	14
BKUP	8.97	8.47	10	13.2	8.67
RCMN	18.07	14.8	15.57	20	19.56
LYTY	18.6	19.2	17.14	20	20
INFO	14.03	14.07	11.14	20	17
LSTD	18.2	18.13	18	20	18.22
INTR	15.23	14.87	16.71	20	18.22

Figure 5.12


AVERAGE OF THE RANKS AWARDED
ENGINEERING
TEXTILES
PROCESS
SERVICES
PRNT. & PKG
RANKS AWARDED (1 - 20)
25
20
15
10
5
0
PRIZ
QLTY
DDTE
MTOD
FNCE
CPST
MGTE
TKCE
SMTK
SIZE
GOLK
PIND
REPS
HNST
BKUP
RCMN
LYTY
INFO
LSTD
INTR

The derived positions of the factors are shown in table 5.12 in page 144 overleaf. They were also transformed into a bar chart and presented in figure 5.13 in page 145. Again, there were no clear patterns as were observed in figures 5.6 and 5.7 respectively.

See pages 144 and 145.

Further statistical analysis was performed to establish whether the respondents agreed on the order of the ranks. An analysis using the same Spearman's Rank Order Correlation Coefficient (Rs) was conducted,

where:

$$Rs = 1 - \frac{6\sum d^2}{n(n-1)(n+1)} \qquad \text{---------------} (01)$$

The results derived from the calculations are shown in table 5.13 in page 146.

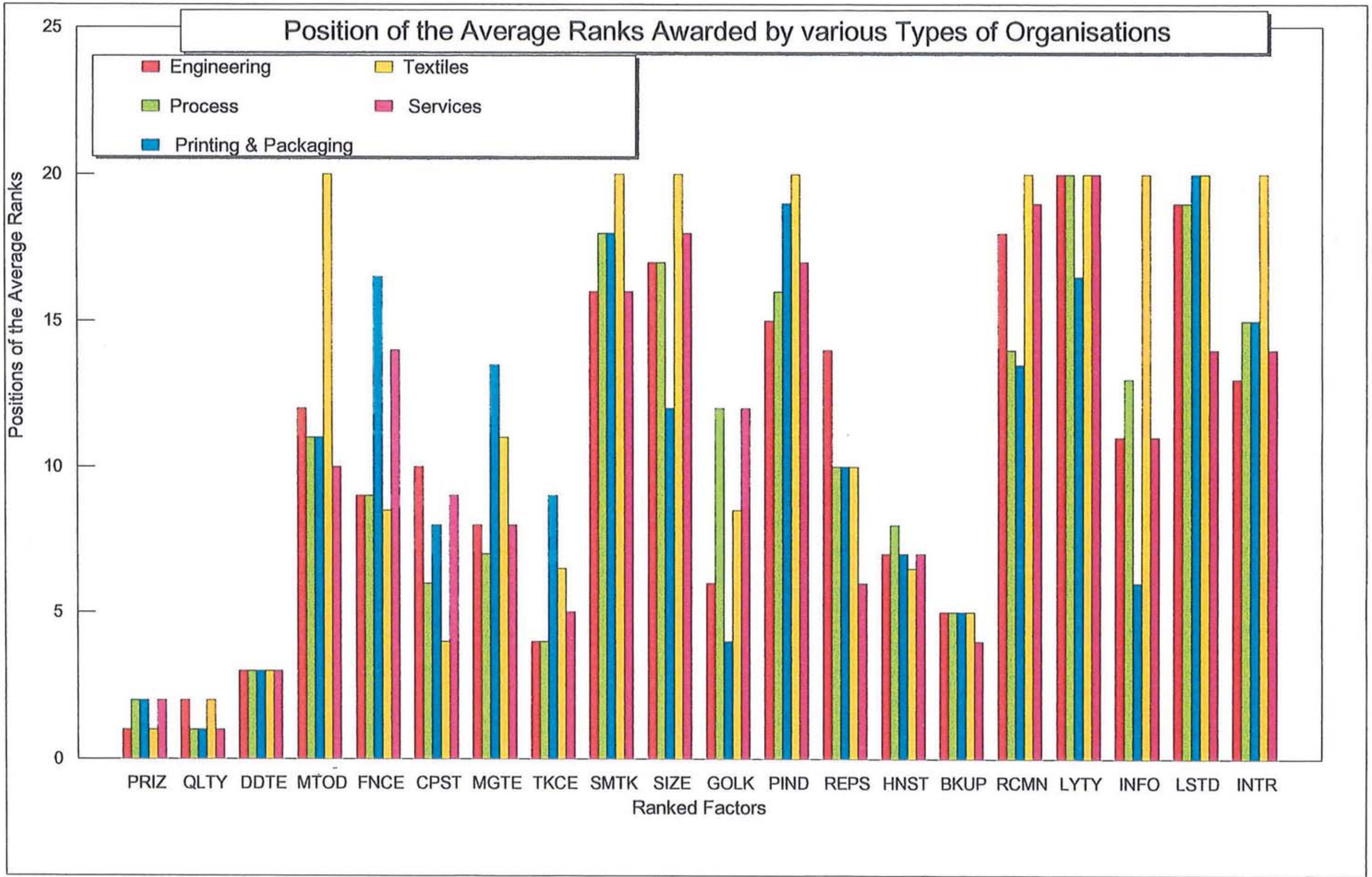
See page 146.

Table 5.12

POSITION OF THE AVERAGE RANKS AWARDED BY THE ORGANISATIONS

Ranked Factors	Types of Organisations which Awarded the Ranks				
	Engineerin	Proces	Printing & Packagin	Textil	Servic
PRIZ	1	2	2	1	2
QLTY	2	1	1	2	1
DDTE	3	3	3	3	3
MTOD	12	11	11	20	10
FNCE	9	9	16.5	8.5	14
CPST	10	6	8	4	9
MGTE	8	7	13.5	11	8
TKCE	4	4	9	6.5	5
SMTK	16	18	18	20	16
SIZE	17	17	12	20	18
GOLK	6	12	4	8.5	12
PIND	15	16	19	20	17
REPS	14	10	10	10	6
HNST	7	8	7	6.5	7
BKUP	5	5	5	5	4
RCMN	18	14	13.5	20	19
LYTY	20	20	16.5	20	20
INFO	11	13	6	20	11
LSTD	19	19	20	20	14
INTR	13	15	15	20	14

Figure 5.13



Position of the Average Ranks Awarded by various Types of Organisations
Engineering
Textiles
Process
Services
Printing & Packaging
Positions of the Average Ranks
0
5
10
15
20
25
PRIZ QLTY DDTE MTOD FNCE CPST MGTE TKCE SMTK SIZE GOLK PIND REPS HNST BKUP RCMN LYTY INFO LSTD INTR
Ranked Factors

5.4.2. INFERENCES ON ANALYSIS BY TYPE

Table 5.13. The correlations between the ranks in organisations of different types.

TYPES OF ORGANISATIONS	PROCESS	PRINTING & PACKAGING	TEXTILES	SERVICES
ENGINEERING	0.923	0.815	0.757	0.875
PROCESS		0.783	0.802	0.913
PRINTING & PKG.			0.594	0.786
TEXTILES				0.714

The degree of correlations between the ranks awarded by these types of organisations varied from modest to very high. The interpretations of these values of correlations are represented by table 5.7 in page 128. The conclusions therefore is that a high correlation exists in the rankings awarded by these respondents. This suggests that the different types of organisations broadly agreed on the order of the ranks awarded to the various factors.

Further investigations and statistical analysis were performed on the acquired data. All the calculations are included in the appendix 2 to 5.

Friedman's Two-Way Analysis of Variance by Ranks, Cohen & Holliday (1982) was introduced to assess the extent of variations in the way the ranks were awarded. The test statistic:

$$X_r^2 = \frac{12H}{NK(K+1)} - 3N(K+1) \qquad \text{----------- (03)}$$

Where;

N = number of rows (which is 5),

K = number of columns(which is 20)

R^2 = the square of the rank total,

H = the sum of the square of the rank total, i.e $\sum R^2$

The calculations achieved the value of 114.33. This value was then compared with the table value of 30.14 (of χ^2 Distribution) at 5% significant level. See appendix 3. This result suggested that there was a significant difference in the ranks awarded, and that the different industry types had a uniform view about the most significant factors.

Kruskal-Wallis One-Way Analysis of Variance by Ranks (H) was again used for further analysis on the variations of the ranks. See equation (02) in page 130.

Table 5.14 The calculated results on differences in the way the factors were ranked.

VARIABLES/FACTORS	ACHIEVED RESULTS (H VALUES)
PRIZ	4.47
QLTY	3.03
DDTE	1.58
MTOD	4.93
FNCE	4.86
CPST	8.63
MGTE	3.51
TKCE	3.97
SMTK	3.53
SIZE	5.98
GOLK	7.91
PIND	4.74
REPS	3.00
HNST	0.53
BKUP	9.34
RCMN	9.57
LYTY	5.97
INFO	6.35
LSTD	2.51
INTR	4.66

The results shown in the above table were compared with the significant value of the Friedman statistic H which is 9.488, based on the χ^2 value at 95%

level (ie. α = 0.05) with 4 degrees of freedom. The results indicated that there was no significant difference in the way the factors were ranked by the various types of organisations, with one exception in the way that the factor_ Recommendation from Friends and Relatives (RCMN) was ranked. This factor achieved the calculated value of 9.57 which was more than the table value of 9.488. Process and Printing & Packaging organisations rate this factor significantly more important than the other groups do.

Further statistical analysis was carried out by using Kendall's Coefficient of Concordance W,

$$W = \frac{\sum (R_j - \frac{\sum R_j}{N})^2}{\frac{1}{12}K^2(N^3 - N)} \qquad \text{------------ (04)}$$

where: Rj = sum of the ranks for sample j

k = the number of populations

N = the number of items in all the samples

A calculated value of 83.25 was achieved. This result was then compared with the χ^2 table figure of 36.19 at α = 0.01 with 19 degrees of freedom. The result confirmed that there was a set of factors which matter irrespective of the types of organisation. For example, all respondents agreed that the factors;_ Product Price (PRIZ), Quality (QLTY) and Delivery Dates (DDTE) were more important than any others.

5.4.3. PRICE AND QUALITY DETERMINATION

When the respondents were asked to disclose, in question 4, how they chose a suitable price, all of them from the Textiles and Services groups stated that they determine a suitable price by comparing prices from different suppliers and then choosing the lowest. 90%, 93% and 85% of the respondents from Engineering, Process and Printing & Packaging industries respectively, determine a suitable price by comparing different prices also. Fifteen percent of the organisations from Printing and Packaging industries answered that they would fix the price that would suit their programme and then urge their suppliers to meet that target. Figure 5.14 in page 151 shows the percentage of how organisations from various industries determine a suitable price. See figure 5.14 overleaf.

On the issue of determining the quality of the suppliers' services, as before, two choices were provided in the questionnaire, ie.

. by using the number of defective items (or rejects) as a ratio of the total delivery, or

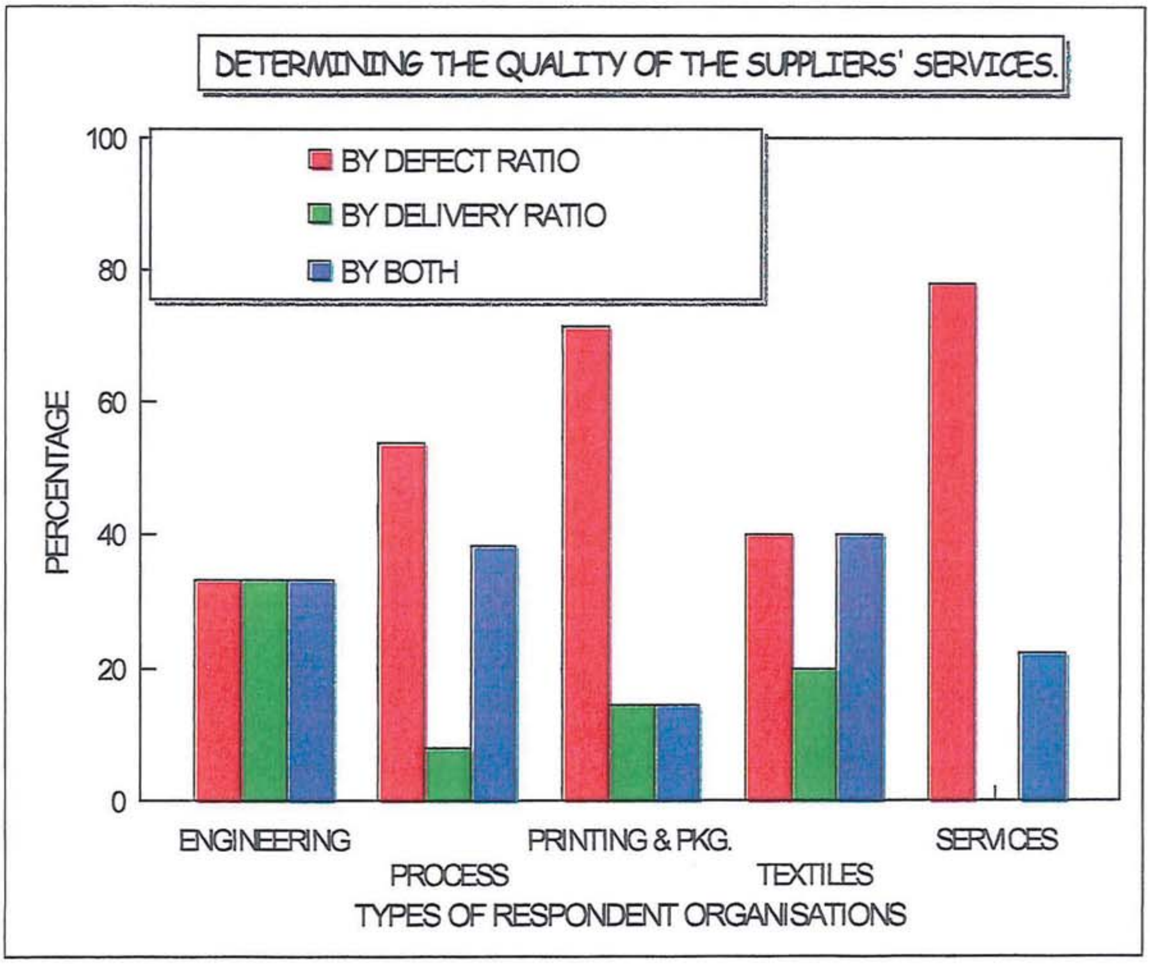
HOW VARIOUS TYPES OF ORGANISATIONS DETERMINE A SUITABLE PRICE.

Figure 5.14.

. by using the number of items delivered as agreed as a ratio of the total requisition.

Three different answers were observed and recorded because some organisations use both methods stated above. See figure 5.15 below.

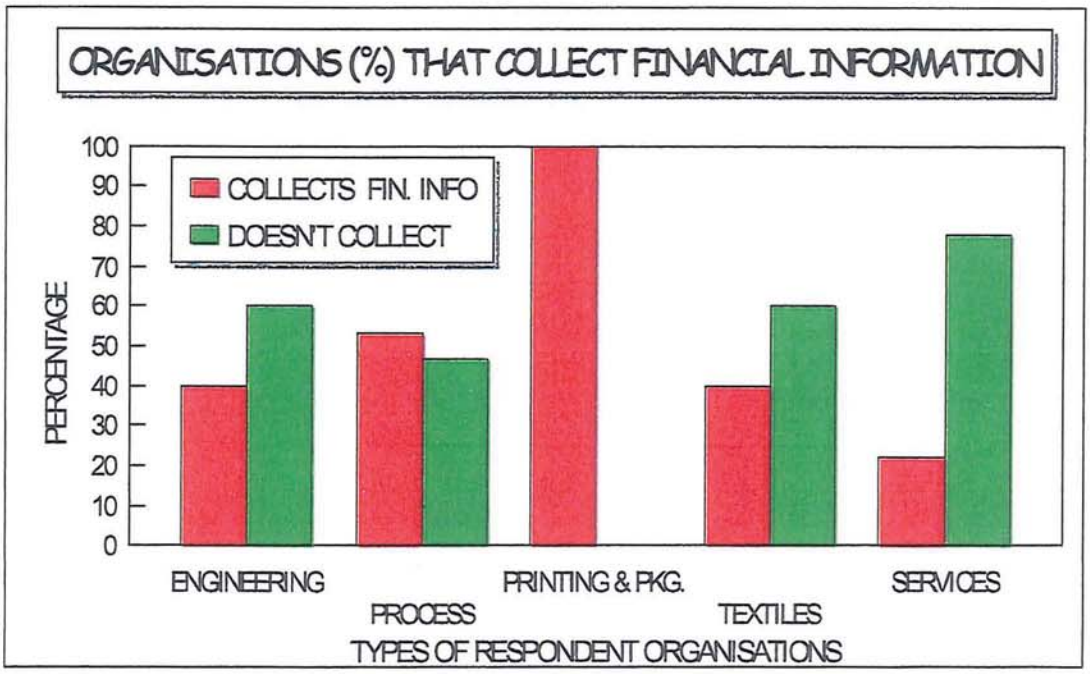
Figure 5.15.



The above chart shows the percentage of organisations in each industry group who responded that they used methods one or two or both, (already explained) in determining the quality of the services of their suppliers.

The percentage of each type of organisation that collected financial information about their suppliers are shown by figure 5.16 below.

Figure 5.16.



5.4.4. AWARENESS OF EXPERT SYSTEMS & WILLINGNESS TO USE IT

The question intended to find out the level of awareness of expert systems within different types of organisations revealed the following results:

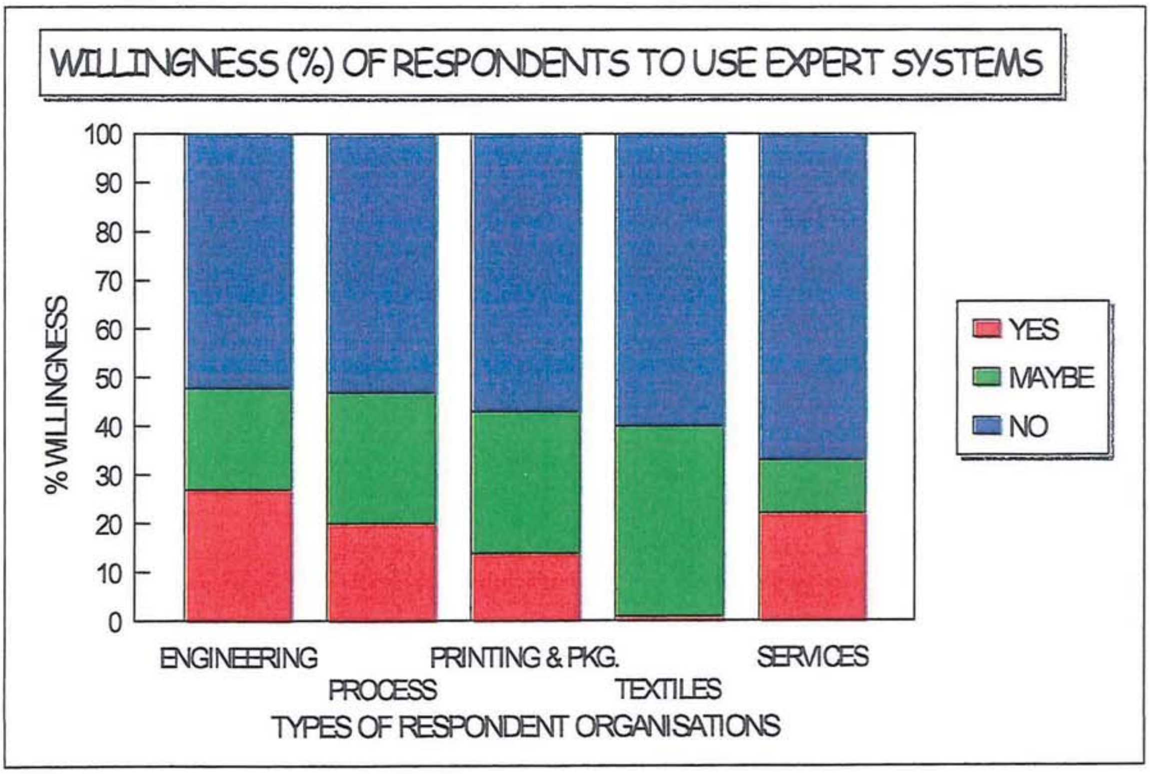
TYPES OF ORGANISATION	% AWARENESS OF E.S.
Engineering	21
Process	20
Printing & Packaging	14
Textiles	00
Services	44

Table 5.15. E.S. Awareness.

The results in table 5.15 in page 153 suggest that the most aware group of the technology are those in the Services industries, followed by the Engineering, the Process and then the Printing & Packaging organisations respectively. The Textiles group is yet to be informed of the technologies of expert systems.

Question 13 in the survey questionnaire asked the respondent organisations whether they would use the expert systems technology to tackle the problem of vendor selection, if it was developed. The achieved results were presented in figure 5.17 in the form of a stacked bar chart. See figure 5.17 below.

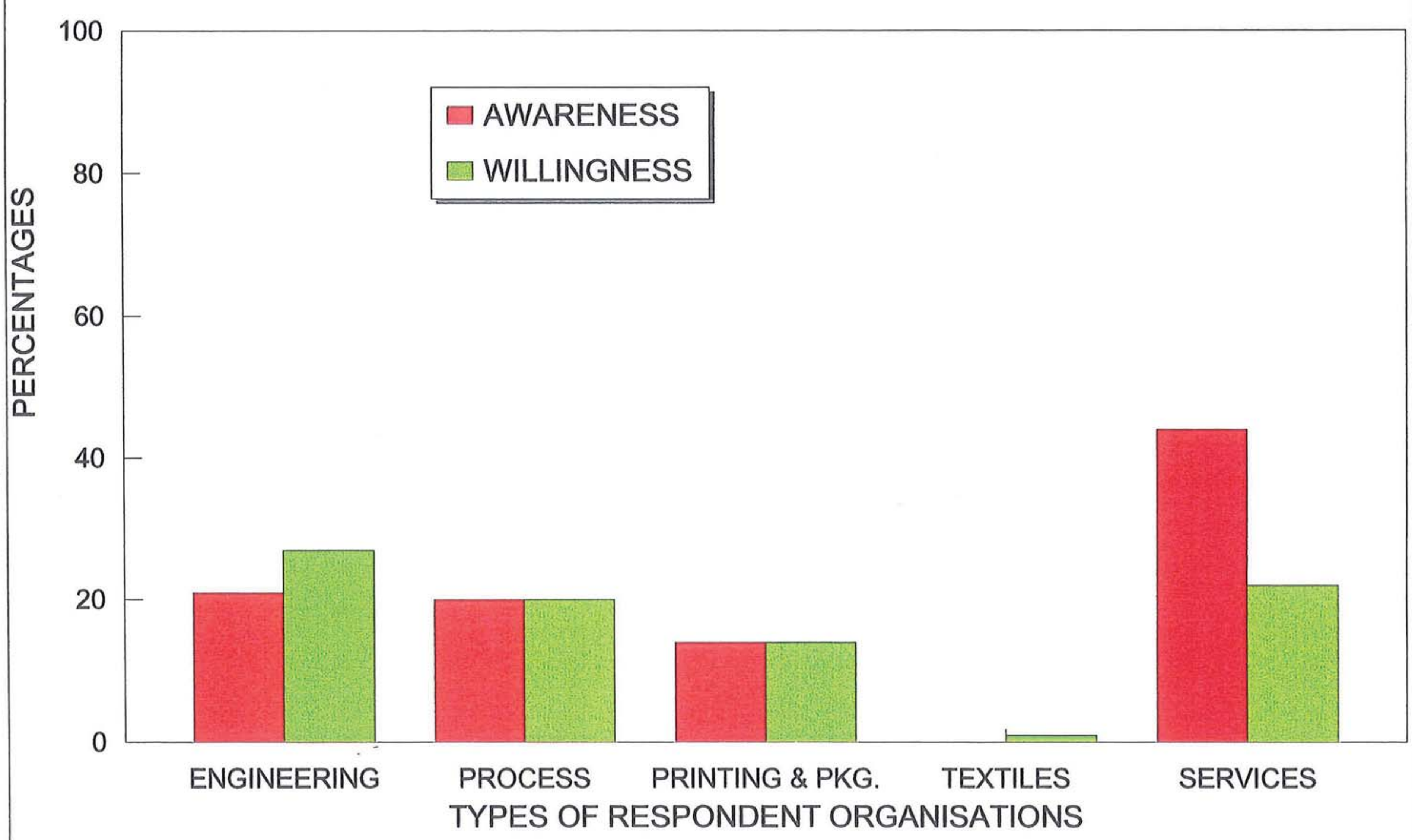
Figure 5.17.



The above chart includes responses from the organisations which are unsure whether they would use the system or not, if it is developed. The textiles industries admitted that they would not use expert systems for solving vendor selection problems. This is understandable because they are not aware of the technology. However, almost 40% of them accepted that they may use the system. It also happened that the most aware group (ie the Services group) is the not the most enthusiastic to use the technology.

Looking back to the case for analysis by size in page 138 (figure 5.11), it also happened that the most aware group appeared to be the most unwilling to use the system. One could therefore assume that, perhaps, expert systems may have had a negative publicity in the past. Figure 5.18 in page 156 overleaf, shows the percentage awareness of, and the willingness to use Expert Systems for solving vendor selection problems within different types of organisations.

Figure 5.18 AWARENESS OF E.S. & WILLINGNESS TO USE E.S.



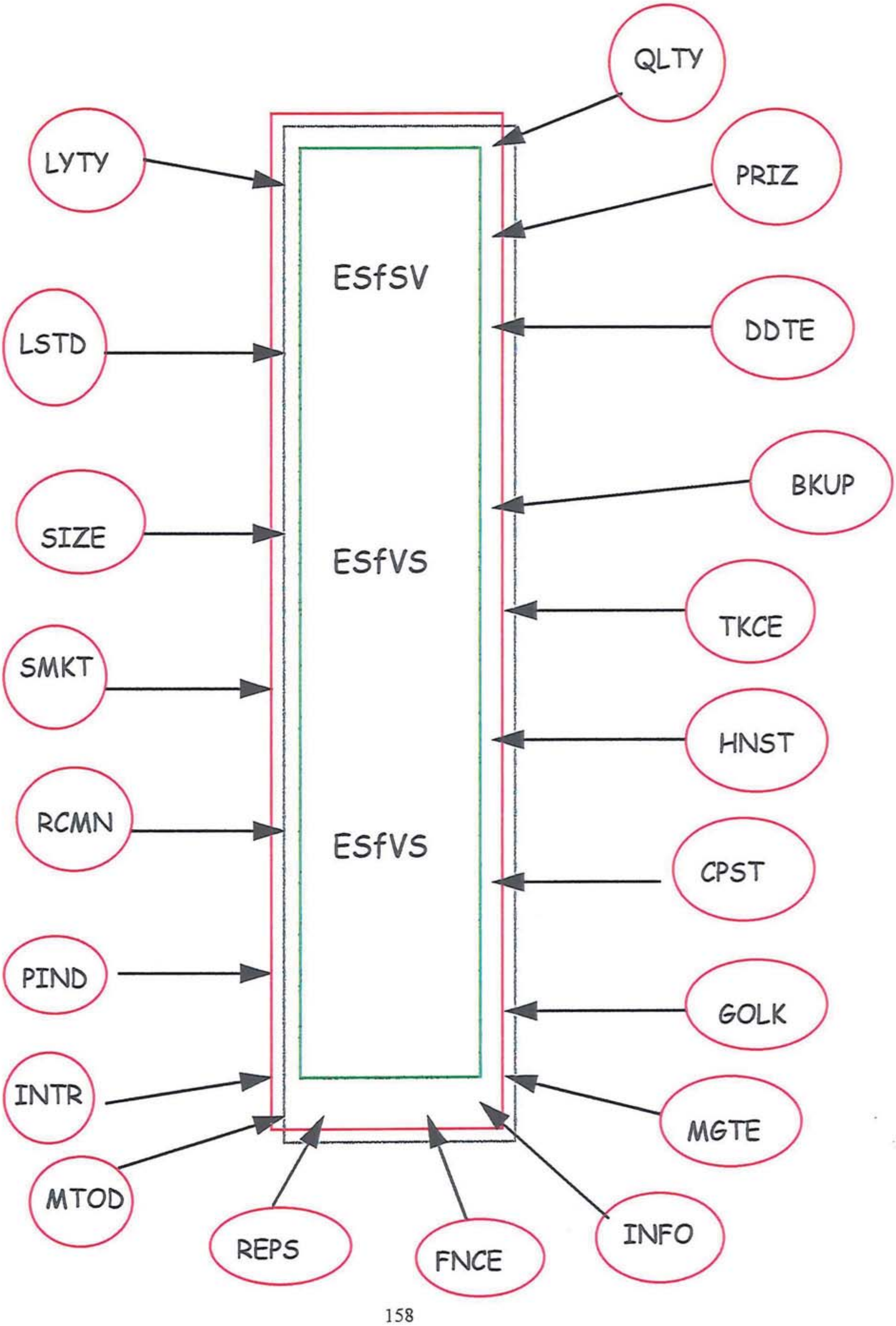
5.5 DEVELOPMENTS

The factors which are considered during the process of selection and evaluation of a potential supplier(s) have been identified and analysed. They are listed in table 5.2 in page 117. Even the least important LYTY (ie. Loyalty to Friends or Relatives) was taken into account by 17% of the respondents. As a result, any system to be developed for helping to solve the problem of vendor selection should incorporate those factors. The conceptual representation of such system, ie. Expert Systems for Vendor Selection (ESfVS) is demonstrated in figure 5.19 in page 158

Each of the factors has features which need to be satisfied in order to acknowledge the importance of that particular factor. For instance, Quality (QLTY) requirements should address issues of how well the technical specifications of a product are met, how well the product performs (ie. against the set standard performance), the reliability and/or consistency of a product, etc. The Price factor (PRIZ) should analyse the actual product price, discounts, etc which determines the amount of money paid for a product, etc. as explained earlier in sections 2.1 and 5.2.

All these sub programs (with their features) together form the ESfVS.

Figure 5.19. VENDOR SELECTORS' DECISION VARIABLES



The performance of the program, as mentioned earlier, should be based on the features of the twenty factors. This may involve developing twenty sub programs. As one of the main objectives of the research project included investigating the perception of using expert systems capabilities for solving vendor selection problems, it was necessary to demonstrate the system's applicability in the domain. Due to time constraint and resource limitation it was not possible to build twenty sub programs (ie. the entire system). The time allocated for the research and the resources available for the program development were such that a complete Expert System for Vendor Selection cannot be developed. In addition, some factors would be very specific to a particular industry or even organisation. For this reason, the decision to build a prototype of one of the sub programs was made. This prototype would act as a test trial to establish:

+ whether the program would work, and if it worked;

+ how people would react to it

+ the commercial viability of the system.

It was also anticipated that the prototype would help in increasing the knowledge and awareness of expert systems in vendor selection.

After making the decision to develop a prototype for one of the twenty factors, it was necessary to choose which factor to experiment with. To make this choice, the analysis of the ranked factors was re-visited. The factor which showed a highly significant difference in the way it was ranked by different sizes of the organisations, the factor which had the most distinct pattern in figures 5.27 and 5.28 was chosen. It is the factor that assessed the financial background of the prospective supplier(s) __ The Financial Background (FNCE).

Large organisations already investigate the financial background of their potential suppliers. The analysis in page 134 suggested that the larger the size of organisations, the more of a requirement it is for them to collect the financial information. Collecting such information is not a common practice in small firms (only 2 out of 18 in the smallest category do it), presumably, due to lack of expertise. The system would therefore serve the dual purpose of providing the expertise for the small organisations and also making a breakthrough into using expert system programs for addressing vendor selection problems.

The FNCE factor is also relatively independent of the nature or the size of the business, unlike the Price or Quality, where expertise could be specific to a given industry. The need to know whether a potential supplier(s) has the financial capacity to supply the desired quality product(s) at the required time and place should not be limited to only large firms, or to any specific industry. Against these backgrounds, the choice to develop a prototype of FNCE was favored rather than developing a prototype of any of the other variables.

At this juncture, the question of what constitutes a good financial background became an issue that required another thorough investigation. Hence the next phase of the programme was devoted to assessing and determining the characteristics of good financial background.

6. ANALYSIS OF FINANCIAL BACKGROUND

It is a legal requirement, according to Holmes & Sugden (1984), for companies to publish financial statements of their yearly trading. The company's annual report and accounts is usually the principal way in which:

. Shareholders

. Management

. and other interested parties such as:

- Suppliers
- Inland Revenue
- Banks
- Employees
- Acquisition and Merger Groups
- etc

keep themselves informed of the financial position of any company in which they have interest, Lumby (1990). This yearly financial information is in the form of Profit and Loss Account, Balance Sheet and, in most cases, the Chairman's Statements and/or Director's Report, Auditors' Report and Statement of Accounting Policies.

These provide the general idea of:

. the size of a company

. the company's capital structure

. its profitability

. etc.

The historical summary (if provided) reveals whether a company is:

. growing

. cyclical

. stagnant or

. declining.

6.1. THE METHODS OF ANALYSIS

An assessment of a company's financial position should focus on the company's performance over certain trading periods, Lee (1984) as well as a comparison with other similar companies, Holmes et al (1984). The methods employed in this analysis which involve the use of percentages and ratios, Begg et al (1987) are:

* Horizontal Analysis

* Trend Analysis

* Vertical Analysis

* Ratios.

6.1.1 HORIZONTAL ANALYSIS

This is a method of comparing (on a line-by-line basis) the current year's accounts with those of the previous trading periods. It involves working out the percentage change of every major component of the accounts. The percentage change per se does not reveal the overall performance of a company. However, it is very vital in prompting further investigations. In the example below, (table 6.1) for instance, further enquiries are needed as to:

+ why the trading profit fell by more than 2% when turnover rose by almost 10% in the period.

Table 6.1 Horizontal Analysis

	HORIZONTAL ANALYSIS			
	1993	1994	DIF.(^)	(^).%
	£	£	£	(%)
TURNOVER	286000.0	314000.0	28000.0	9.8
TRADING PROFIT	50125.0	48956.0	-1169.0	-2.3
INT. PAID - INV. INCOME	8500.0	11015.0	2515.0	29.6
PROFIT BEFORE TAXATION	41625.0	37941.0	-3684.0	-8.9
TAXATION	7492.5	5691.2	-1801.3	-24.0
PROFIT AFTER TAXATION	34132.5	32249.9	-1882.6	-5.5
EXTRA-ORDINARY ITEMS	1335.0	2125.0	0.0	

+ Could the 29.6% increase in interest paid be attributed to more borrowing or higher interest rates, or lower investment income, or a combination of the above.

+ Why was there a significant difference between the decline in taxation and that of pre-tax profit. Was there an ACT written off or recovered in either years.

+ What caused the value of the extra-ordinary items to increase, were re-organisation costs included, eg. variety reduction, discontinuation of certain loss makers, etc.

+ Despite 8% fall in the attributable profit why was there a significant increase in the shareholders dividends.

Answers to these sort of questions should be taken on board when making the final determination.

6.1.2 TREND ANALYSIS

Millichamp (1984) believed that horizontal analysis can be extended over several trading years. When more than two years of a company's accounts are compared, and the figures for the first year are given a base value of 100 so that the figures of the subsequent years are scaled accordingly, the term Trend Analysis comes into being, Begg et al (1987). This is calculated by dividing each preceding year's figures by that of the first year, and then multiplying the result by the base of 100.

Table 6.2 Trend Analysis

	TREND ANALYSIS				
	1990	1991	1992	1993	1994
TURNOVER (£000)	198	219	255	286	314
INDEX (1990, BASE = 100)	100	110.6	128.8	144.4	158.6
TRADING PROFIT(£ 000)	33.1	39.9	48.4	50.1	49
INDEX (1990, BASE = 100)	100	120.5	146.2	151.4	147.9

As table 6.2 depicts, profit rose from 33.1 in 1990 to 48.4 (achieving 21.3% growth) in 1992 when it was growing alongside the increasing turnover. After 1992, the rate of profit growth slowed down. While turnover continued to grow from 255 in 1992 to 286 in 1993 (achieving 12.16% growth), profit only rose by 3.5% in 1993. The decline in profit continued and became more evident when it fell from 50.1 in 1993 to 49 in 1994, recording a negative growth rate of minus 2.2%.

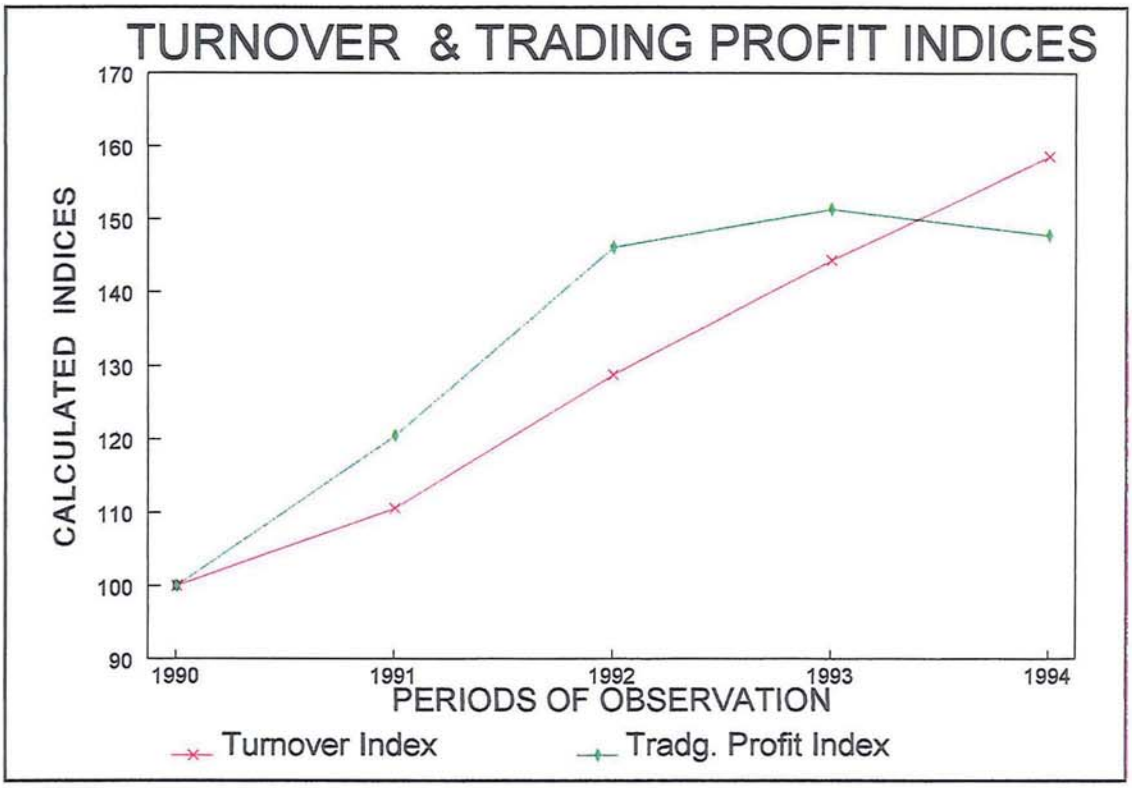


Figure 6.1 Turnover/Profit Indices

6.1.3 VERTICAL ANALYSIS

In this method, every item in the Balance Sheet is expressed as a percentage of the balance sheet total, Wood (1982), and every item in the Profit & Loss Account is also expressed as a percentage of the total income. This method assigns the value of 100 to the balance sheet and income totals such that each item in either accounts statements assumes a percentage of the assigned value, ie. 100.

The use of vertical analysis over several years helps to show how the financial structure of a company is changing.

	VERTICAL ANALYSIS			
	1993	1994	1993	1994
	(£,000)	(£,000)	%	%
CAPITAL EMPLOYED:				
Share Capital	44	73	30.8	42.9
Reserves	38	31	26.6	18.2
Shareholders' Funds	82	104	57.3	61.2
Loan Capital	39	36	27.3	21.2
Short Term Borrowing	22	30	15.4	17.6
TOTAL	143	170	100	100

Table 6.3 Vertical Analysis I.

	VERTICAL ANALYSIS			
	1993	1994	1993	1994
	(£,000)	(£,000)	%	%
REPRESENTED BY:				
Land and Buildings	57	61	39.9	35.9
Plant and Machinery	41	46	28.7	27.1
Fixed Assets	98	107	68.5	62.9
Investments	3	9	2.1	5.3
Stks,debtors-Creditors	42	54	29.4	31.8
TOTAL	143	170	100	100

Table 6.4 Vertical Analysis II.

6.1.4 THE USE OF RATIOS

The Balance Sheet and the Profit and Loss Account each usually contain a minimum of ten to twenty items, Lee (1984), Wood (1982),Holmes et al (1984) and Lumby (1990). The scope for comparing one item with another is tremendous. Thus it is important to be selective so as to limit the calculations involved and to make the presentation of the selected ratios simple and understandable.

Ratios can be divided into the following groups:

* Operating Ratios,

  which deal with how a company is trading, and take no account of how the company is financed.

* Financial Ratios,

  which measure the financial structure of a company and show how it relates to the trading activities.

* Investment Ratios,

  which relate the number of ordinary shares and their market price to the profits, dividends and assets of a company.

6.1.4.1 OPERATING RATIOS

. Trading Profit

Sales (Turnover)

Here, Trading Profit refers to profit before interest charges and taxation, investment income and the company's share of profits from associated companies are not included. Sales (Turnover) which excludes transactions within the groups.

. Trading Profit

Capital Employed

This expresses the Return on Capital Employed (ROCE) as a percentage. If the result is lower than the cost of borrowing, increased borrowing will reduce earnings per share (e.p.s.). It serves as a guide to a company in assessing possible acquisitions and or starting up new ventures.

. Sales (Turnover)

Capital Employed

In this case, increasing ratio suggests an improvement in the company's performance.

. Stocks

Sales (Turnover)

Stocks are made up of:

. raw materials and consumable

. purchased components

. work-in-progress

. finished goods

. goods for re-sale

. Trade debtors
---------------- (usually x 260, ie. working days/year).
Sales (Turnover)

This measures the level of debt a company incurs, and how quickly it can collect the funds owed to it.

. Trade creditors

Sales

This demonstrates the level of credit a company is allowed by its suppliers.

. Working capital

Sales

Working Capital = Stocks + Trade debtors - Trade creditors.

This is an indication of how much capital a company requires to finance operations in addition to capital invested in fixed assets. Hence, a falling ratio could reveal overtrading.

. Trading Profit

Wages

This shows a direct reflection of the effect of wage increase on profit.

. Debtors

Creditors

Sudden changes here could trigger a warning signal depending on the nature and the direction of the change.

Sales per Employee and Trading Profit per Employee are also useful ratios as their trend gives some indication of changing productivity.

6.1.4.2 FINANCIAL RATIOS

These falls into two major categories namely, Gearing and Liquidity.

Gearing is concerned with

/ the proportion of capital employed that is borrowed,

/ the proportion divided by the shareholders' funds,

/ and the relationship between the two.

Financial gearing can be described as;

a) $$\frac{\text{Borrowing}}{\text{Shareholders' Funds}}$$

b) the percentage of capital employed represented by borrowing. Hence, a company with low gearing is one which is financed predominantly by equity, while a highly geared company is one which relies on borrowing for a substantial proportion of its capital.

Liquidity is concerned with a company's cash position. It describes the extent to which a company can pay its debts as they fall due.

. Quick ratio or Acid test

$$\frac{\text{debtors + cash}}{\text{current liabilities}}$$

This ratio assesses how quickly a company can convert its assets into cash to meet urgent demands. Not all current assets can be readily converted into cash, Stein (1984), hence stocks are excluded from the equation. If the ratio after computation is less than one, then the company would not be able to meet its immediate debt payment obligations. However, certain terms and conditions of trading can allow a company to sell goods for cash before paying for them, Samuelson (1976) and Begg et al (1987). This is illustrated in table 6.5 below. In this case, the company can afford to operate at a quick ratio of less than one since it is allowed to purchase on credit and then sell the goods before paying for them.

	STILMET INT. LTD._QUICK RATIOS OVER 5 YEARS				
YEAR End 31 Dec.	1990	1991	1992	1993	1994
Debtor+Cash (£k)	70.1	98.8	118	173.8	207.6
Cur. Liabilities (£k)	77.6	112.1	125.8	182.2	241
QUICK RATIOS	0.9	0.88	0.94	0.95	0.86

Table 6.5 Quick Ratio Illustration

. Current ratio

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

The current asset ratio is also known as the working capital ratio which is an indicator of a company's short term financial position. A ratio of more than one would suggest a surplus of current assets over current liabilities. Nowadays, a ratio of => 1.5 is regarded as prudent according to Lumby (1990), Lee (1984) and Smith & Begg (1988) in order to maintain credit worthiness. Table 6.6 is an example of a company showing the assets and liabilities from which the prudent current ratios were derived.

	HARDIS LTD._CURRENT RATIOS OVER 5 YEARS				
YEAR End 31 Dec.	1990	1991	1992	1993	1994
Current Assets (£k)	200.7	220.8	282	315	384.3
Current Lblities (£k)	132	130.7	158.4	190.3	216.4
CURRENT RATIOS	1.52	1.69	1.78	1.65	1.77

Table 6.6 Current Ratio Illustration.

However, a high ratio does not necessarily represent a very good sign. It could mean;

* excessive stock
* excessive debtors
* large amount of cash which could be more profitably invested
* combination of the above, etc.

Much could also depend on a number of factors within the company, for example;

+ the nature of the company's business
+ the type or quality of the current assets
+ the imminence of current liabilities
+ the volatility of working capital requirements, etc.

In studying an individual company's current ratio, there is no clear cut rule as to what the company's ratio should be. However, the level of the current ratio should be monitored on a yearly basis since it would reveal a growing or declining trend. A declining trend could indicate a warning signal which should not be ignored. The reason why changes occur is another matter which warrants further investigation. For instance, low or declining trends often illustrate rising bank overdraft. In which case an enquiry into the bank's stance on the issue could be pursued, or perhaps a statement in the annual report by the chairman or the auditors or others could allay the fears in this direction.

. Cashflow

To inquire further into a company's liquidity, it is necessary to examine the cashflow. The two common definitions of cashflow, according to Holmes and

Sugden (1984) are:

1). Gross Cashflow_ ie. depreciation + profit after tax

+ increase in deferred tax.

2). Net Cashflow_ ie. Gross cashflow - dividends.

The three main areas to consider when analysing whether a company can meet its current financial requirements are:

. Repayment of existing loans.

. Increase in working capital.

. Capital expenditure requirement.

However, a company may, if the net cashflow falls short of the cash requirements:

. raise its overdraft

. borrow on longer term basis

. sell some assets

. reduce capital expenditure

. improve credit and stock management,

. etc.

6.1.4.3 INVESTMENT RATIOS

These ratios are used by investors and their advisers in making investment decisions such as whether to:

. buy shares

. hold on to shares

. sell shares.

Usually, they consider the current price of the shares and as such change continually in line with the supply and demand of the shares. The two most vital ratios are Price Earnings Ratio and Dividend Yield.

\ Price Earnings Ratio is the Price of one share divided by profit attributable to one share.

$$\text{PER} = \frac{\text{price of one share}}{\text{profit attributable to one share.}}$$

\ Dividend Yields are based on gross dividends per share, ie. on the actually paid dividends plus the associated tax credit.

$$\text{Gross dividend yield (\%)} = \frac{\text{Net dividend in pence/share * 100}}{\text{(1-basic tax rate)* ordinary share p/p}}$$

\ Dividend Cover

$$= \frac{\text{Earnings per share}}{\text{Net dividend per share}}$$

\ Payout Ratio

$$= \frac{\text{Net dividends}}{\text{Profit after tax}}$$

\ Net Asset Value (n.a.v.)

$$= \frac{\text{ordinary shareholders' funds (OSF)}}{\text{number of ordinary shares issued}}$$

6.1.5 CONCLUDING REMARKS

To determine a vendor(s) with good financial background, the knowledge of what constituted a good financial background had to be acquired in the first instance. The data required to use this knowledge could be in the form of Company's Balance Sheet, Profit & Loss Account, or other financial statements from individual companies and/or company directors. Access to this financial information could be obtained from:

Companies House,

Dunn & Bradstreet

Direct from the Supplier

Infotech Services Ltd.

Infocheck

Compass

Financial Times

or from any other source.

Credit analysts, accountants, etc. look at the annual financial statements of companies and or other records and then provide an indication of their financial position. These professionals make such judgements based on their knowledge and experience of the subject. It is this knowledge and experience that our program is intended to capture and store in the Knowledge Base for use by non-experts in the area. Hence, the idea of using expert systems to make such a determination is to provide the purchasing personnel with a tool to enable them make a quick and instant decision, which would normally require the services of those in the finance and credit rating industry.

The next stage of the research programme concentrates on translating the acquired knowledge into an Expert Systems program.

7. BUILDING THE SYSTEM

After acquiring the relevant knowledge about assessing the financial position of an organisation, the next phase of the project was to organise and translate this knowledge into an expert systems program. This section of the thesis describes the design and development process of the system - A prototype expert systems program for the sub program FNCE which is for determining the financial background of a prospective supplier(s).

7.1 THE SYSTEMS DESIGN CONCEPT

Discussions from the previous chapter established that for a company to be regarded as one with a good financial background, it must have:

sufficient working capital, and

good gearing structure.

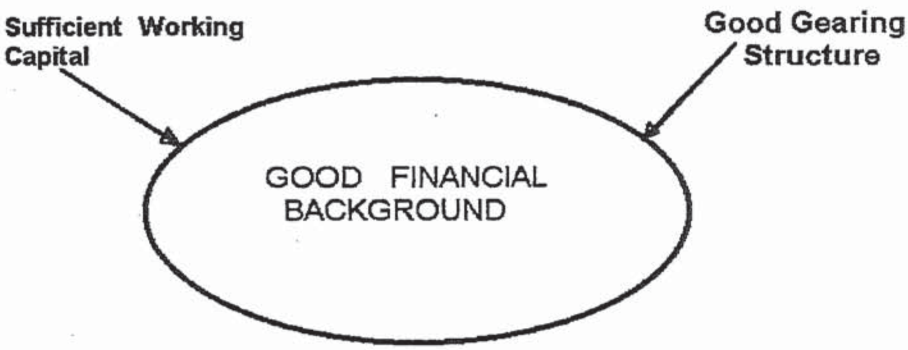


Figure 7.1 Conceptual View

Working capital and gearing are the vital elements for assessing a company's financial position. The former addresses the cash position of a company and the extent to which it can pay its debts as and when due. Gearing, on the other hand, is concerned with the source of the capital employed in the business. For example, a highly geared company is predominantly financed by loan, hence one would expect a company with sound financial background to have a low gearing.

The working capital/liquidity ratios and the gearing level should be determined by the individual organisation because any ratio or gearing percentage which is acceptable to one company may not be acceptable to another due to differences in company activities, methods and standards.

For example, page 174 in the previous chapter explained how

"... *certain terms and conditions of trading can allow a company to sell goods for cash before paying for them*...",

hence, creating opportunities for somewhat peculiar working capital / liquidity ratios. This vindicates the fact that differences in these ratios between organisations are not uncommon.

7.2 SYSTEMS DESIGN

The discussion in chapter 6 established that a quick look by experts (ie professionals in Finance and/or related discipline) at the financial ratios of a company would reveal whether the company is financially balanced or not, and so the system to be developed should be able to examine these ratios and then determine the company's financial status.

As the financial ratios and gearing structures differ between organisations, Lumby (1990), it was decided to design the prototype with fixed values for ratios and percentages, and then modify them accordingly to suit an individual organisation's requirements. However, these percentages and ratios can be changed from time to time in order to reflect any current trading condition. An organisation known as Universal Resource Management Ltd, a Bolton based company, provided the researcher with its past statements of accounts. It was from these statements that the ratios and the percentages used at this stage of the research were derived. Acceptable values for the ratios and the percentages used at this initial stage of the design are:

the current ratio of 0.8 or more

the quick ratio of 0.5 or more

the loan capital of 60% or less

For the assessment of a company's financial position to be realistic, a historical analysis of the company's performance should be taken into account. The length of the trading periods to be studied could range from two to ten years or even more. It is up to the individual organisation to set the historical period for observation. For the purpose of the prototype, three years trading period was deemed appropriate for observation. See figures 7.2, 7.3 and 7.4.

Figure 7.2 Requirements for Prudent Current Ratio.

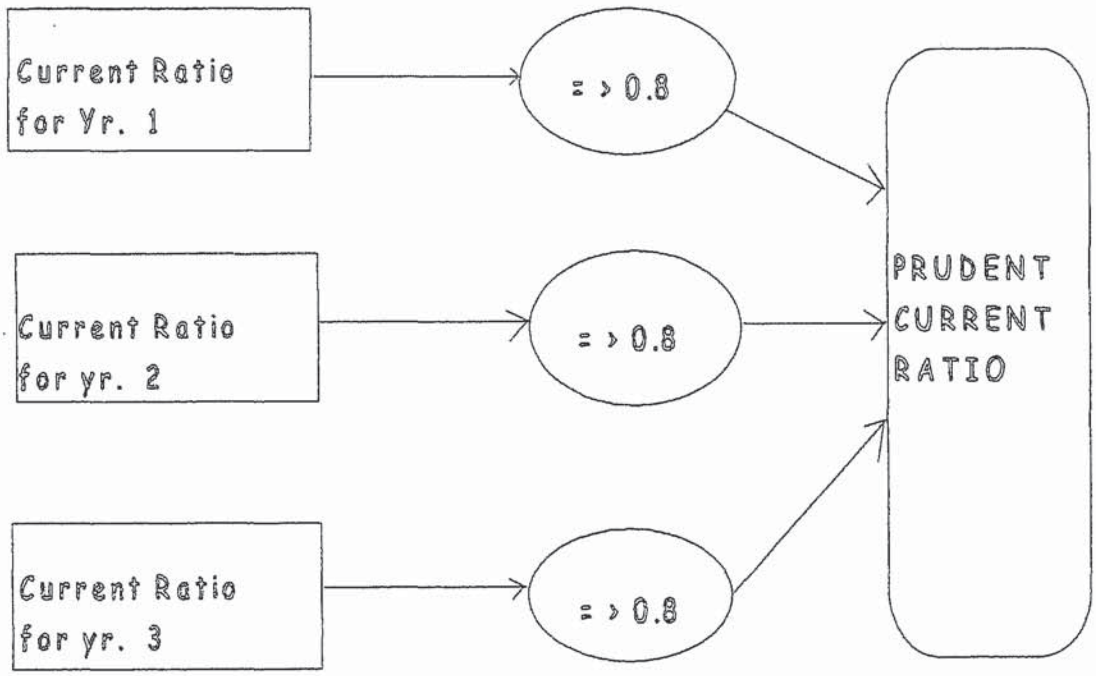


Figure 7.3 Requirements for Good Quick Ratio.

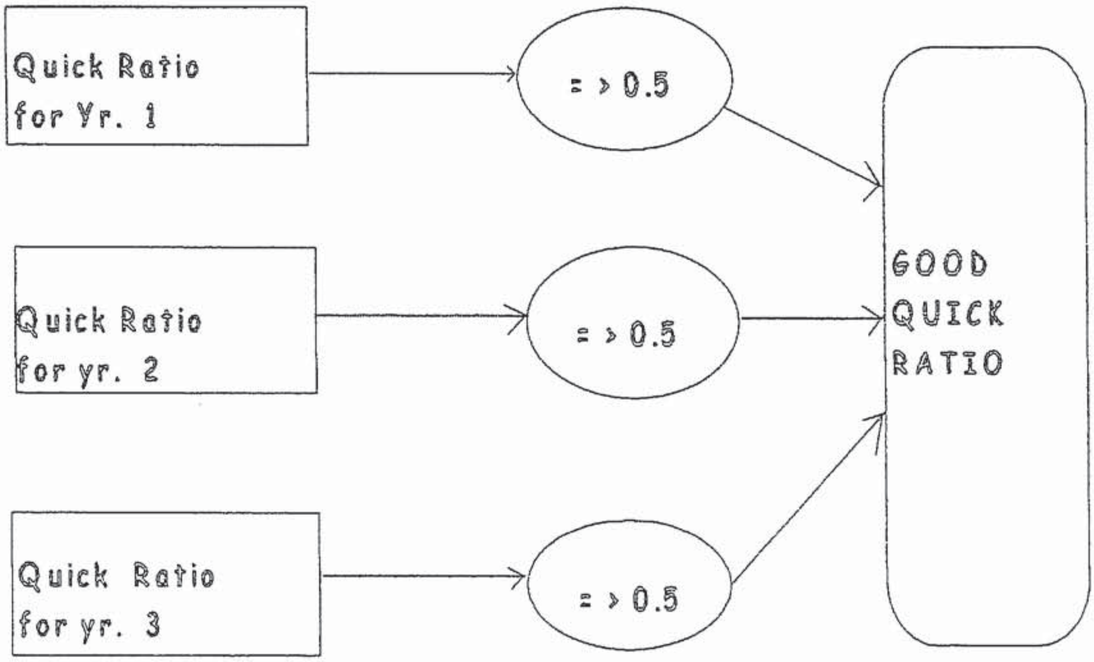
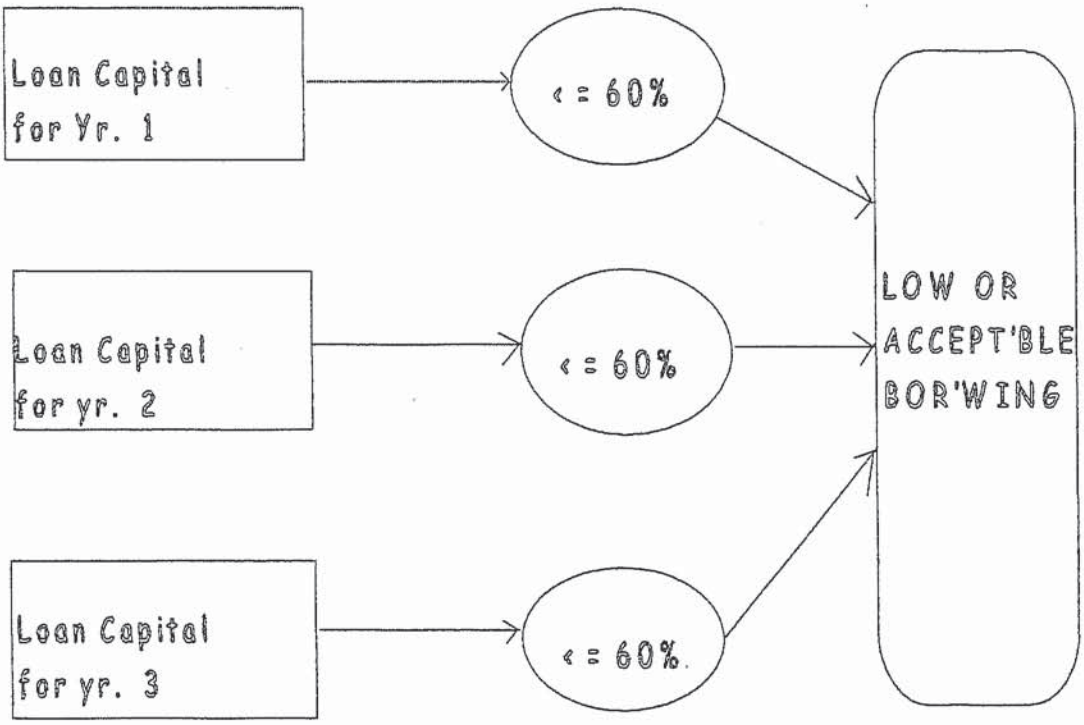


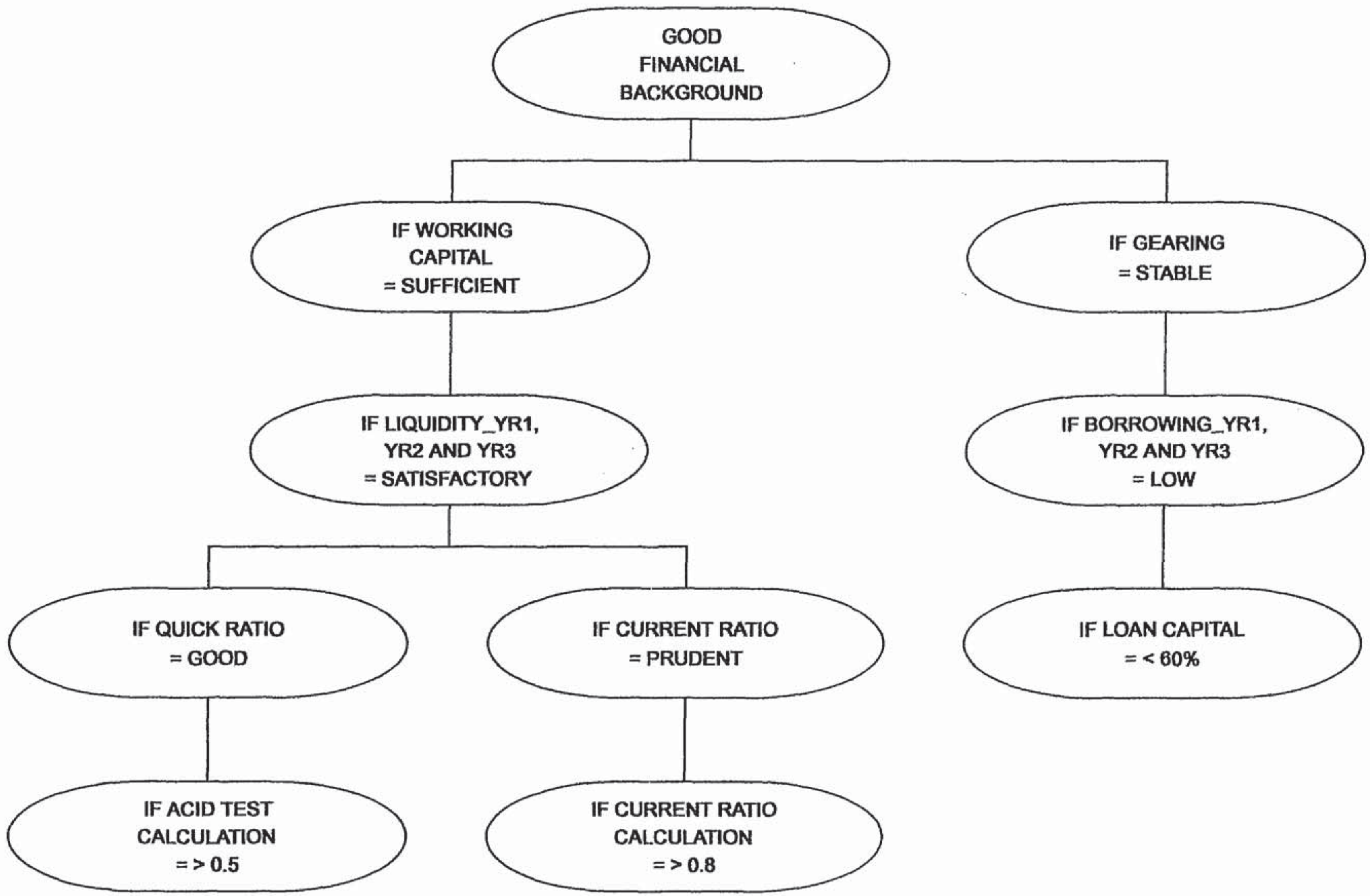
Figure 7.4 Requirements for Acceptable Borrowing Level.



As explained previously, it should be expected that these ratios and percentages would differ from one organisation to another. The rates should be fixed by individual organistions, and modified periodically to accommodate various standards, as well as to keep up with ever changing business situations. For example, some organisations would probably not want to have the same rates and percentages for all the years under consideration. They might prefer higher rates for year one and lower rates for year two and/or three, and vice visa. Some organisations might consider more than three years or less during their analysis of data, etc. Whatever the case may be, it would be up to the individual organisation to set and modify these parameters.

Figure 7.5 in page 187 overleaf represents the model of our prototype systems design concept, using the rates already mentioned and three years' data..

Figure 7.5 SYSTEMS DESIGN CONCEPT



However, it would not be appropriate for a company to decline from trading with another simply because the latter has not been in business for up to three years. One can deal with a firm which, perhaps, has only one year trading experience, provided the volume of the business does not exceed a pre-determined limit. That is to say, the level of commitment should be such that any failure or disappointment could be absorbed without far reaching consequences. For example, a firm could decide not to award contract(s) of more than £2K, or £5K, as the case may be, to a company with less than one year, or two years, or even five years of trading experience.

In this program, for instance, if a company has not been in business for up to 3 years, then a decision on its financial background can still be made based on a combination of other factors. For example, if the first year's data is not available [N/A] (due to lack of activities, etc.) or below the required ratio or percentage, but the second year's figures meet the criteria and the third year's data is better than the second year's, then the financial position would be accepted as being good. Figures 7.6, 7.7 and 7.8 demonstrate the acceptable criteria under the two-year requirements. See the figures in page 189 overleaf.

Figure 7.6 Requirements for Prudent Current Ratio II.

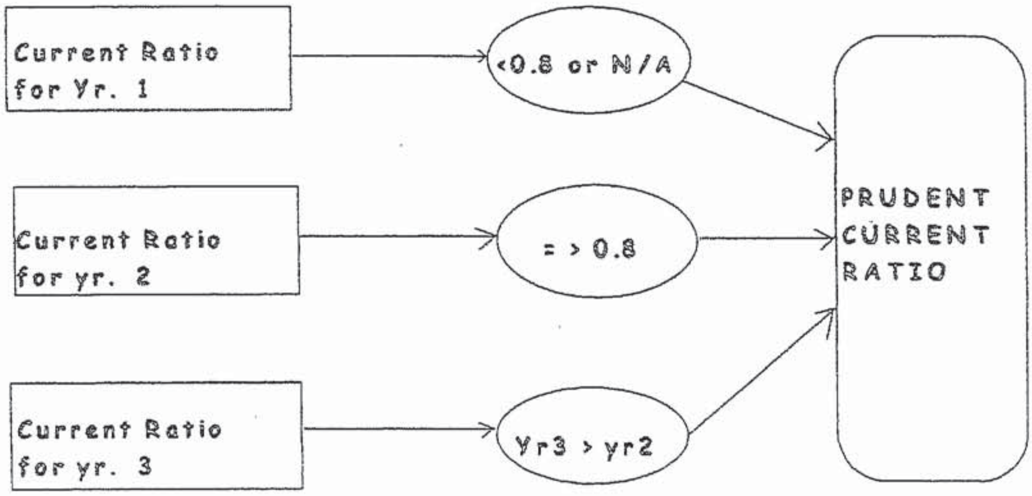


Figure 7.7 Requirements for Good Quick Ratio II.

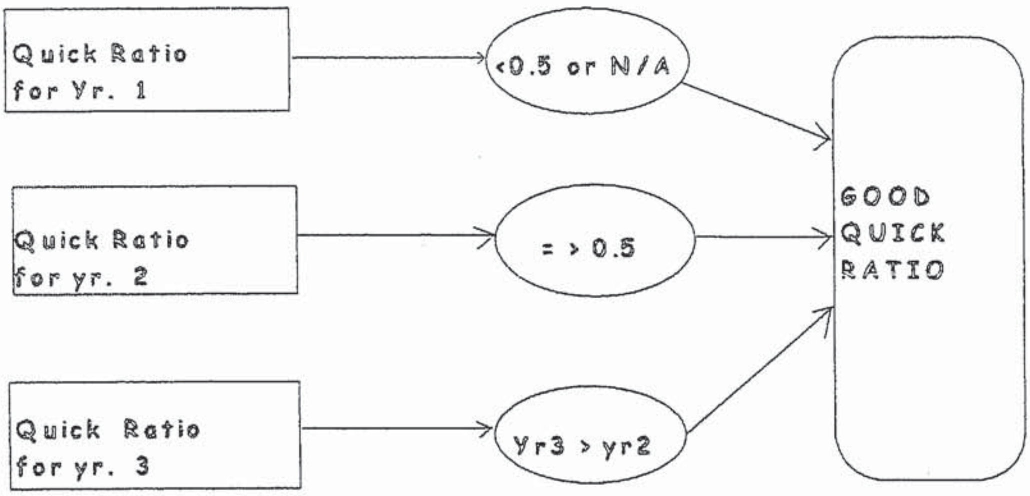
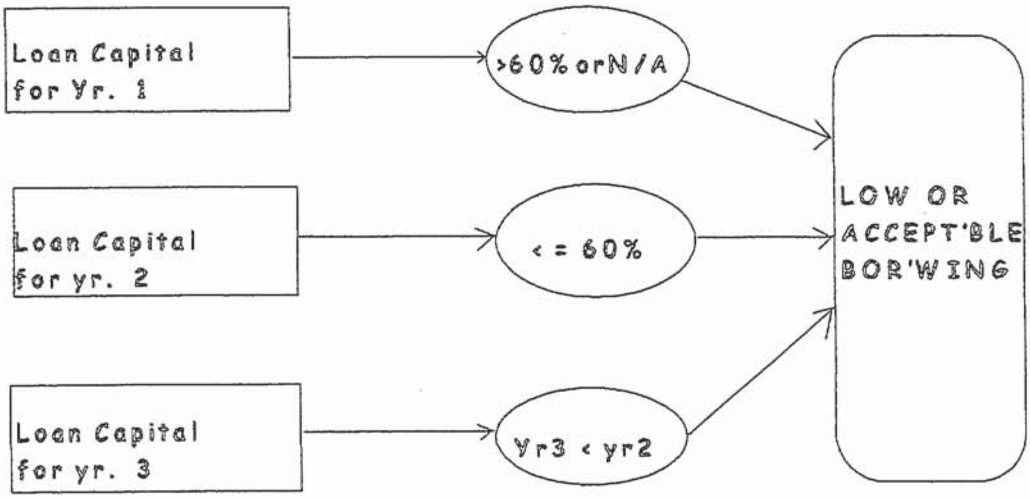


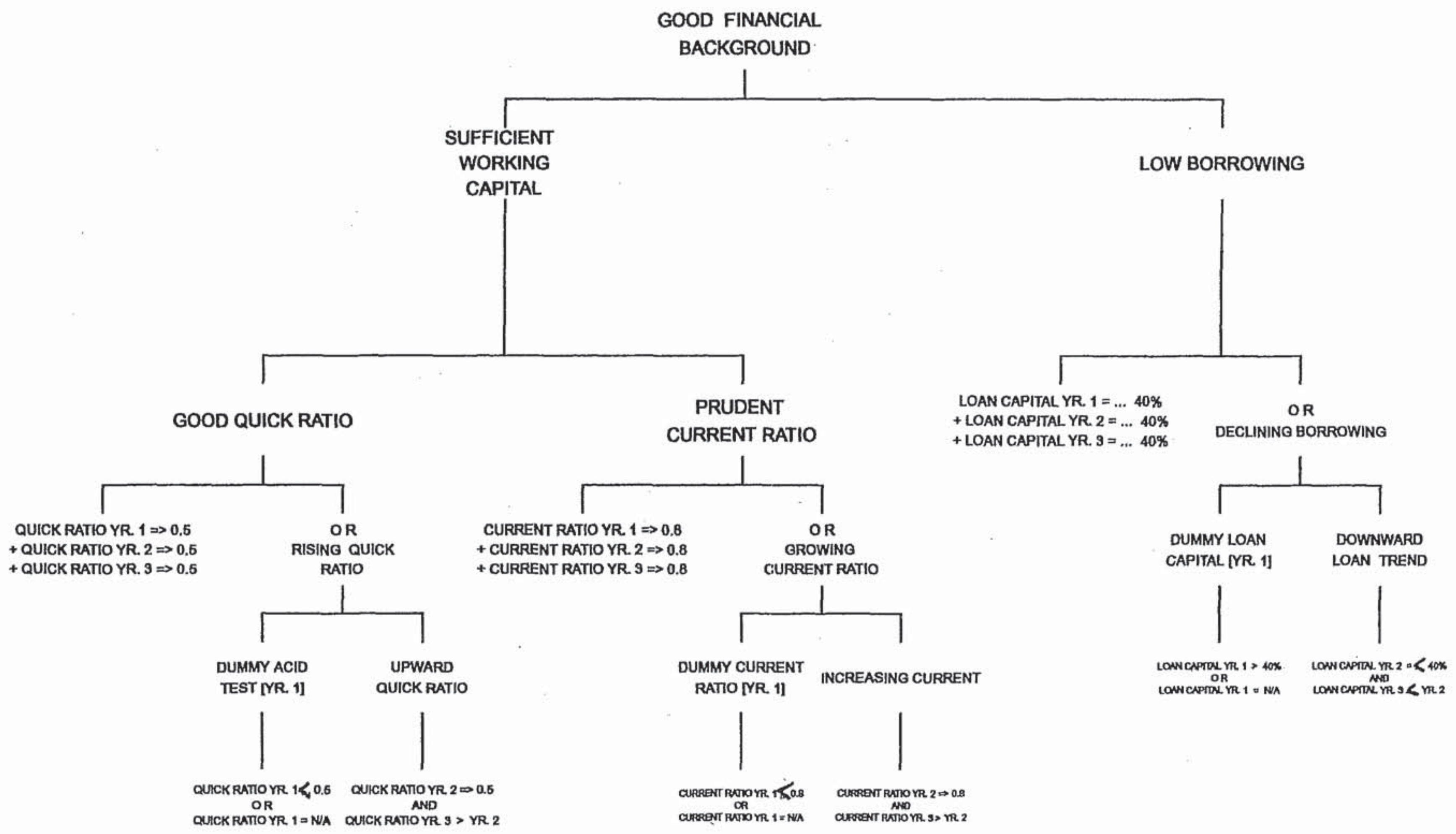
Figure 7.8 Requirements for Acceptable Borrowing Level II.



The system was designed in such a way that it would process three years' data and accept them if they satisfied the already established criteria. Otherwise it would conclude that the financial background was not acceptable. In which case therefore, (ie where the three years' requirements failed), it would then process the two years' plan. It would also draw a favourable conclusion (based on the two previous years' data) provided that the second years' data met the set requirements and the last year's data (ie. the 3rd year) showed improvement on the previous (ie. the 2nd year's). Figure 7.9 in page 191 is a representation of these assumptions.

It is if, and only if, both the three years' and the two years' requirements failed that the system would conclude that the organisation under observation did not have a good financial background.

Figure 7.9 SYSTEMS STRUCTURE



7.3 SYSTEMS DEVELOPMENT TOOLS

A DOS based Personal Computer with 486DX2-66 processor was used for developing the prototype of our model. An Expert Systems development tool (Shell) known as Crystal version 4.5 was used to build the system. An expert systems shell is a computer software package designed for building expert system programs.

Crystal is marketed by Intelligent Environments. Crystal has been widely used for developing Knowledge Base / Expert system programs. For example, it was used by Ernst and Young to develop a system called VATIA which became operational in 1988. VATIA is a PC based expert system for advising clients on V.A.T. issues. Deloittes, according to Jackson (1996) also developed the Budget Adviser expert system for interpreting budget statements using the Crystal shell, in 1988.

The Group Re-Insurance Security Vetting System was developed using Crystal for checking the organisational strength and stability of insurance companies. This system was implemented by Royal Insurance in the late eighties to carry out vetting of other insurance companies involved in group re-insurance. The Crystal developers, Intelligent Environments, used it to build an expert system for ratio analysis for evaluating company's financial performance. The system is called Crystal Company Accounts Analyser.

The decision to use Crystal Version 4.5 was based purely on economic grounds. This is due to the fact that it was the cheapest fully functional expert system development tool available to the researcher. This did not mean that it was the only or the best development tool for building expert systems.

There are other development tools such as; the Leonardo, VP-Expert, EXSYS Professional, EMYCIN, REVEAL, Micro Expert, Expert Ease, Xi Plus, Knowledge Engineering System (KES), Knowledge Engineering Environment (KEE), etc. Other tools in the form of languages for writing expert system programs are Lisp, Prolog, etc.

7.4 FORMULATING THE RULES

Having acquired the relevant knowledge and produced a conceptual design and the structure of the prototype system, attention was then devoted to formulating the rules which to be stored in the Knowledge Base. The parameters (ie the ratios and percentage requirements) for the prototype of our system had already been determined as described in section 7.2. A hard copy of the rule listing is enclosed in the appendix 6. An example of one section of the rules is:

Part 1

IF

Current Ratio for year 1 => 0.8

AND

Current Ratio for year 2 => 0.8

AND

Current Ratio for year 3 => 0.8

THEN

CURRENT RATIO IS PRUDENT

OR

Part 2

IF

Current Ratio for year 1 < 0.8 OR N/A

AND

Current Ratio for year 2 => 0.8

AND

Current Ratio for year 3 > Current Ratio for year 2

THEN

CURRENT RATIO IS PRUDENT.

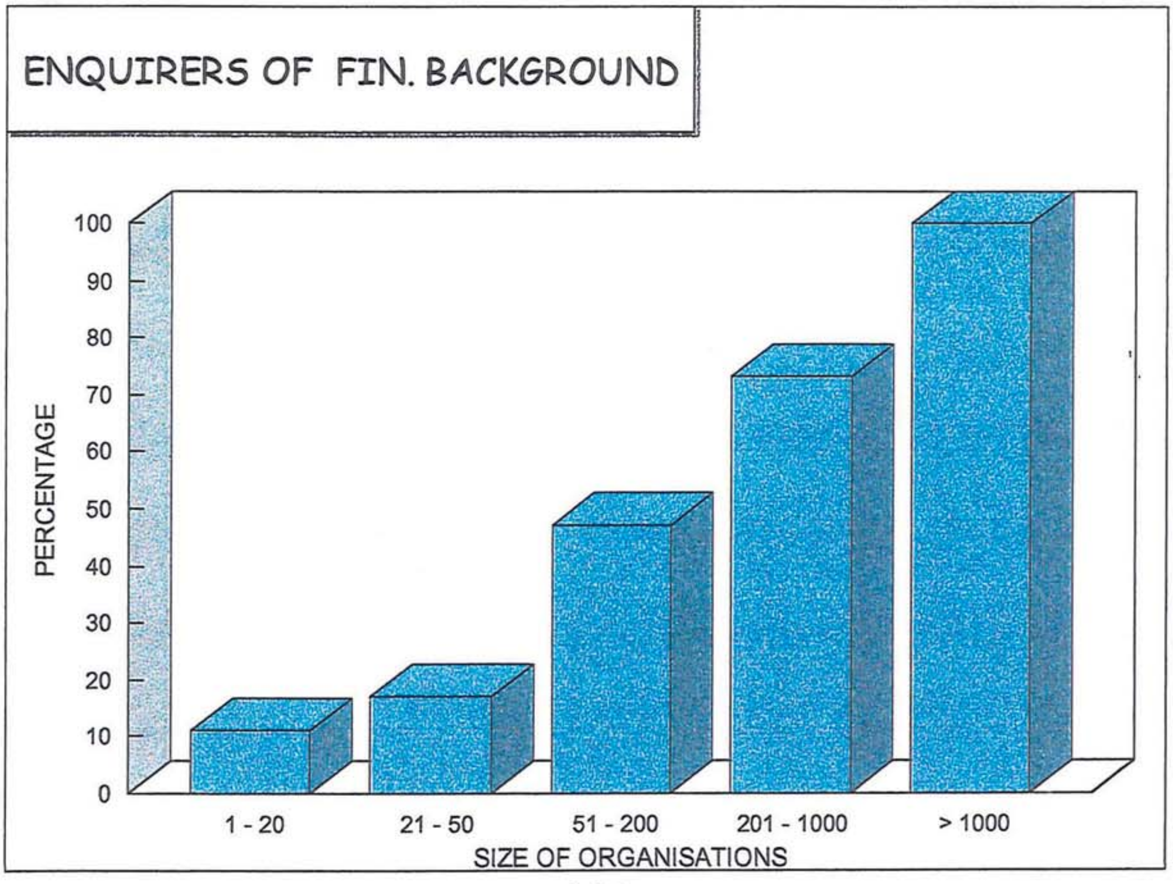
The conclusion < PRUDENT CURRENT RATIO > satisfies the requirements for the current ratios. Similar rule structures were used in accordance with the systems structure in page 191. See figure 7.9. If, for instance, the first condition (or antecedents) of the first part (ie year one figures) fails, then the system will not process the rest of the conditions / antecedents in that part. Instead, it will proceed to the second part (ie the two year plan). If any of the conditions / antecedents here also fails then the system will return a negative conclusion. When both the first and the second parts fail, the system will terminate the processing. It will not process any other rule or rules. This is because the conclusions from the first or the second parts form part of the conditions of other rules in other parts. See the discussion in pages 53 and 54, & the Rule Network, figure 3.6

GOOD FINANCIAL BACKGROUND is the systems' altimate goal /conclusion if all the requirements are met. If, on the other hand, the conditions (ie those that will cause the system to achieve its goal) are not satisfied, then the system will NOT accept the FINANCIAL POSITION as being Good, and thus the processing would end. The system would then tell why it has failed by displaying the results of the analysis and the appropriate comment on the computer screen for the enquirer to see. The print-out of the Rule List in the appendix showed how the rules were organised inside and processed by the System. See appendix 6.

8. SYSTEMS TRIAL

It is considered appropriate at this point to emphasize that the target group for this prototype is the group of small organisations which do not have as much resources as the larger ones. As earlier disclosed by figure 5.10 and discussed further in page 160, large organisations already collect financial information about their suppliers while small organisations do not, presumably, due to lack of expertise. See figure 8.1 below, which was extracted from figure 5.10. The system will therefore help the small firms to acquire this expertise. Hence those who were called upon to test the system came from small organisations.

Figure 8.1



8.1 IN-HOUSE TRIAL TESTS

The system was tested every step of the way during the development stage for errors ranging from spelling, typing, repetitions (eg. of rules, statements, phrases, etc.) syntax, etc. When the program started running, many further tests were conducted by the developer. These test runs were recorded and presented in table 8.1. To successfully determine whether the system met the design specifications, test parameters were established.

8.1.1 TEST PARAMETERS

1). The first test assumed that all the criteria for the Three-Year-Analysis were met. This meant that the:

Quick Ratios for each of Yr1, Yr2 & Yr3 were = > 0.5

and Current Ratios for each of Yr1, Yr2 & Yr3 were = > 0.8

and Loan Capital for each of Yr1, Yr2 & Yr3 were < = 60%.

2). The second test assumed that the Quick Ratio for the first year failed. In this case, the system switched to the Two-Year-Plan where the criteria was satisfied, ie.

Quick Ratio for Yr1 < 0.5 OR N/A (not available)

and Quick Ratio for Yr2 = > 0.5

and Quick Ratio for Yr3 > Yr2

+

Current Ratio for Yr1 $<$ 0.8 OR N/A (not available)

and Current Ratio for Yr2 $=>$ 0.8

and Current Ratio for Yr3 $>$ Yr2

+

Loan Capital for Yr1 $>$ 60% OR N/A (not available)

and Loan Capital for Yr2 $<=$ 60%

and Loan Capital for Yr3 $<$ Yr2

and then concluded GFB (Good Financial Background), if the rules that derived the conclusion fired, otherwise it would be Not GFB. See table 8.1 in page 200 for the summary of the tests and their conclusions.

3). The third test failed the Three-Year-Analysis and then switched to the Two-Year-Plan. It also failed because the requirement for the third year's Quick Ratio was not met. The summary of the in-house test runs can be seen overleaf.

Table 8.1 SUMMARY OF THE IN-HOUSE TESTS AND THEIR CONCLUSIONS

	TEST 1	TEST 2	TEST 3	TEST 4	TEST 5	TEST 6	TEST 7	TEST 8	TEST 9	TEST 10	TEST 11	TEST 12	TEST 13	TEST 14
QUICK RATIO FOR YEAR 1 = > 0.5	Yes	No	No	Yes	No	Yes	Yes	Yes	Yes	NO	Yes	Yes	Yes	No
QUICK RATIO FOR YEAR 2 = > 0.5	Yes	-	-	Yes	-	Yes	No	Yes	Yes	-	Yes	Yes	Yes	-
QUICK RATIO FOR YEAR 3 = > 0.5	Yes	-	-	Yes	-	Yes	-	Yes	No	-	Yes	Yes	Yes	-
CURRENT RATIO FOR YEAR 1 = > 0.8	Yes	-	-	Yes	-	No	-	Yes	-	-	Yes	Yes	Yes	-
CURRENT RATIO FOR YEAR 2 = > 0.8	Yes	-	-	Yes	-	-	-	Yes	-	-	No	Yes	Yes	-
CURRENT RATIO FOR YEAR 3 = > 0.8	Yes	-	-	Yes	-	-	-	Yes	-	-	-	No	Yes	-
LOAN CAPITAL FOR YEAR 1 < = 60%	Yes	-	-	Yes	-	-	-	No	-	-	-	-	Yes	-
LOAN CAPITAL FOR YEAR 2 < = 60%	Yes	-	-	No	-	-	-	-	-	-	-	-	Yes	-
LOAN CAPITAL FOR YEAR 3 < = 60%	Yes	-	-	-	-	-	-	-	-	-	-	-	No	-
QUICK RATIO FOR YEAR 1 < 0.5	-	No	No	-	No	-	No	-	Yes	No	Yes	Yes	Yes	Yes
QUICK RATIO FOR YEAR 1 = N/A	-	Yes	Yes	-	No	-	No	-	-	Yes	-	-	-	-
QUICK RATIO FOR YEAR 2 = > 0.5	-	Yes	Yes	-	-	-	-	-	Yes	Yes	Yes	Yes	Yes	Yes
QUICK RATIO FOR YEAR 3 > YEAR 2	-	Yes	No	-	-	-	-	-	No	Yes	Yes	Yes	Yes	Yes
CURRENT RATIO FOR YEAR 1 < 0.8	-	Yes	-	-	-	No	-	-	-	No	Yes	Yes	Yes	Yes
CURRENT RATIO FOR YEAR 1 = N/A	-	-	-	-	-	Yes	-	-	-	Yes	-	-	-	-
CURRENT RATIO FOR YEAR 2 = > 0.8	-	Yes	-	-	-	Yes	-	-	-	Yes	No	Yes	Yes	Yes
CURRENT RATIO FOR YEAR 3 > YEAR 2	-	Yes	-	-	-	Yes	-	-	-	Yes	-	No	Yes	Yes
LOAN CAPITAL FOR YEAR 1 > 60%	-	No	-	-	-	Yes	-	No	-	No	-	-	Yes	Yes
LOAN CAPITAL FOR YEAR 1 = N/A	-	Yes	-	-	-	-	-	Yes	-	Yes	-	-	-	-
LOAN CAPITAL FOR YEAR 2 < = 60%	-	Yes	-	-	-	No	-	Yes	-	Yes	-	-	Yes	Yes
LOAN CAPITAL FOR YEAR 3 < YEAR 2	-	Yes	-	-	-	-	-	Yes	-	Yes	-	-	No	No
CONCLUSIONS	GFB	GFB	Not GFB	Not GFB	Not GFB	Not GFB	Not GFB	GFB	Not GFB	GFB	Not GFB	Not GFB	Not GFB	Not GFB

The rules were tested and they all fired accordingly. Appropriate conclusions were made when the established criteria were met. When the system was confirmed to be working smoothly, (ie according to the design specifications), it was time to involve outside organisations (ie. the potential users) in the test. The organisations which were approached were those with between one and twenty employees, which, according to the size classification are at the lowest end of the ladder. See figure 8.1. Contacts with this group were established and maintained throughout the development process of the system. The method for selecting the test population was purely on:

(1). The geographical location (Lancashire and Yorkshire)

(2). The size of the organisation (between 1 and 20 employees)

Conducting the tests within the same geographical location was based on economic grounds, as the researcher had to take the test tools to the test sites. This was therefore intended to minimise travelling costs and the associated risks.

Another questionnaire was produced and given to the trial group in order to capture their reactions towards the new system. A copy of this second questionnaire is included in appendix 7. The respondents were required to complete the questionnaire after they had tested the prototype program. Their responses were collected, analysed and reported.

8.1.2 TEST DATA

The researcher approached four companies for their previous financial statements. Extracts from these financial statements were to be used for the tests as the test data. One of them declined to provide such information, which it considered to be very sensitive. The other three companies provided the materials without hesitation. They are:

. Universal Resource Management Limited

. Stilmet International Limited

. Hardis & Dromedas Limited.

The financial statements collected from these organisations in the form of Balance Sheet and Profit & Loss A/c. were used. Another company called Jaykan Plastics Limited used the data from its own past financial statements to conduct the test.

After running the program, the respondents were then asked to complete the follow-up questionnaire. The instructions on how to run the program are also included in the appendix. Questions 1, 2, 3 and 4 are included as an 'ice breaker' and to ascertain the level of computer literacy, as well as to reinforce the reply from the first questionnaire.

8.2 TEST RESULTS

Question 1 was asked in order to find out the number of employees in the purchasing department of the responding organisations. Question 2 was to determine the number of computers or terminals available to the buyers and the purpose of question 3 was to determine how freely the department shares information. Question 4 was designed to establish the number of people in the department who would use the ESfVS when it became fully developed and operational.

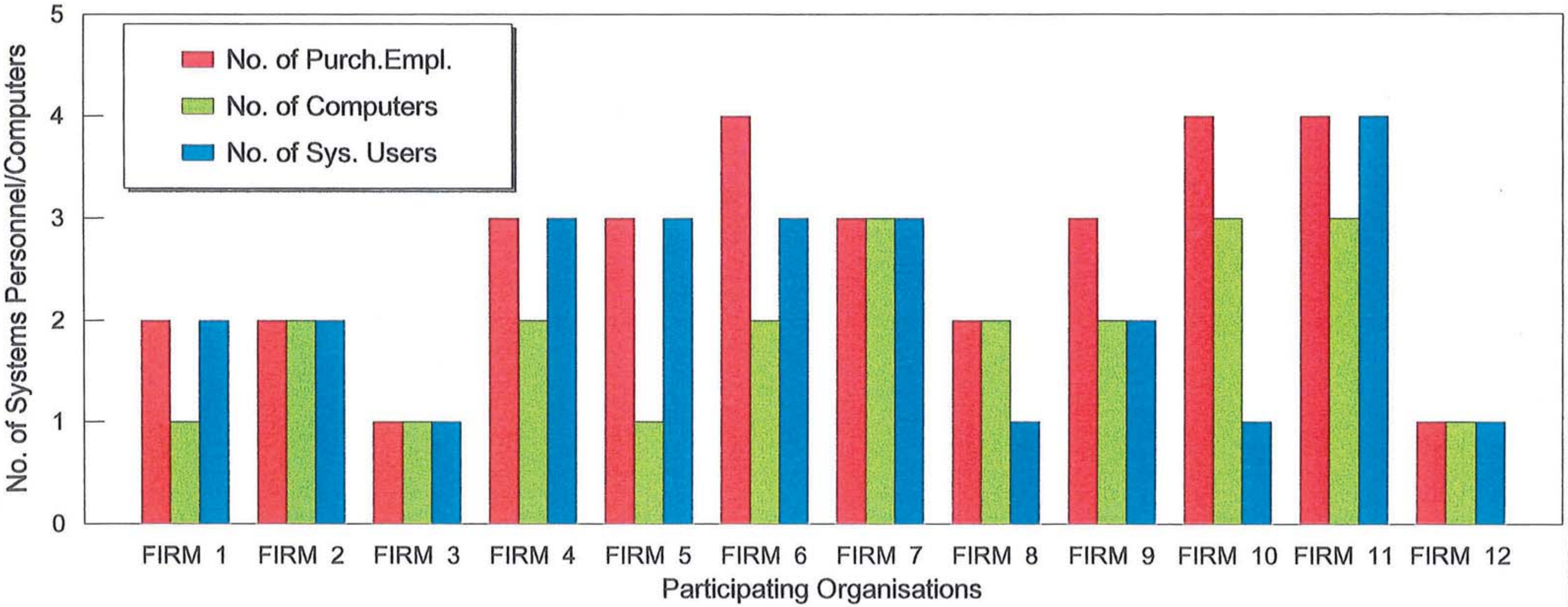
Twelve people from twelve different organisations participated in the test trial. They are referred to as Firm 1, Firm 2, up to Firm 12. Their responses to questions 1, 2, 3 and 4 were recorded in the table 8.2 overleaf. The answers from Firm 1 indicated that there were two employees in their purchasing department. Only one computer was in use by the department but both the purchasing employees would be using the ESfVS when it became operational. Firm 2 has two employees and two computers in the department, and they admitted that they will all use the system. One could therefore infer that the firm 2 made maximum use of computers because it achieved a ratio of one computer per head in the department, and also 100% of the employees would use the expert system if it is available. See table 8.2 overleaf. The data in the table was again transformed to a bar chart which can be found in page 205.

Table 8.2. The Responses to questions 1, 2, 3 and 4.

	No. of Purch.Empl.	No. of Computers	No. of Sys. Users	Special PC?
FIRM 1	2	1	2	NO
FIRM 2	2	2	2	NO
FIRM 3	1	1	1	NO
FIRM 4	3	2	3	NO
FIRM 5	3	1	3	NO
FIRM 6	4	2	3	NO
FIRM 7	3	3	3	YES
FIRM 8	2	2	1	NO
FIRM 9	3	2	2	NO
FIRM 10	4	3	1	YES
FIRM 11	4	3	4	NO
FIRM 12	1	1	1	NO

Firms 2, 3, 7, 8 and 12 have one computer per head in their purchasing departments, and 100% of the employees within the department (except firm 8) would use the program if or when it is fully developed. The comparisons are made more visible by the bar chart in figure 8.2 overleaf.

Figure 8.2 Respondents' Purchasing Employees, Computers and Systems Users



The respondents were asked in question 5 to state what they hoped to achieve by using the system. Five potential achievements were suggested. These are:

. Speed of Processing

. Consistency of Results

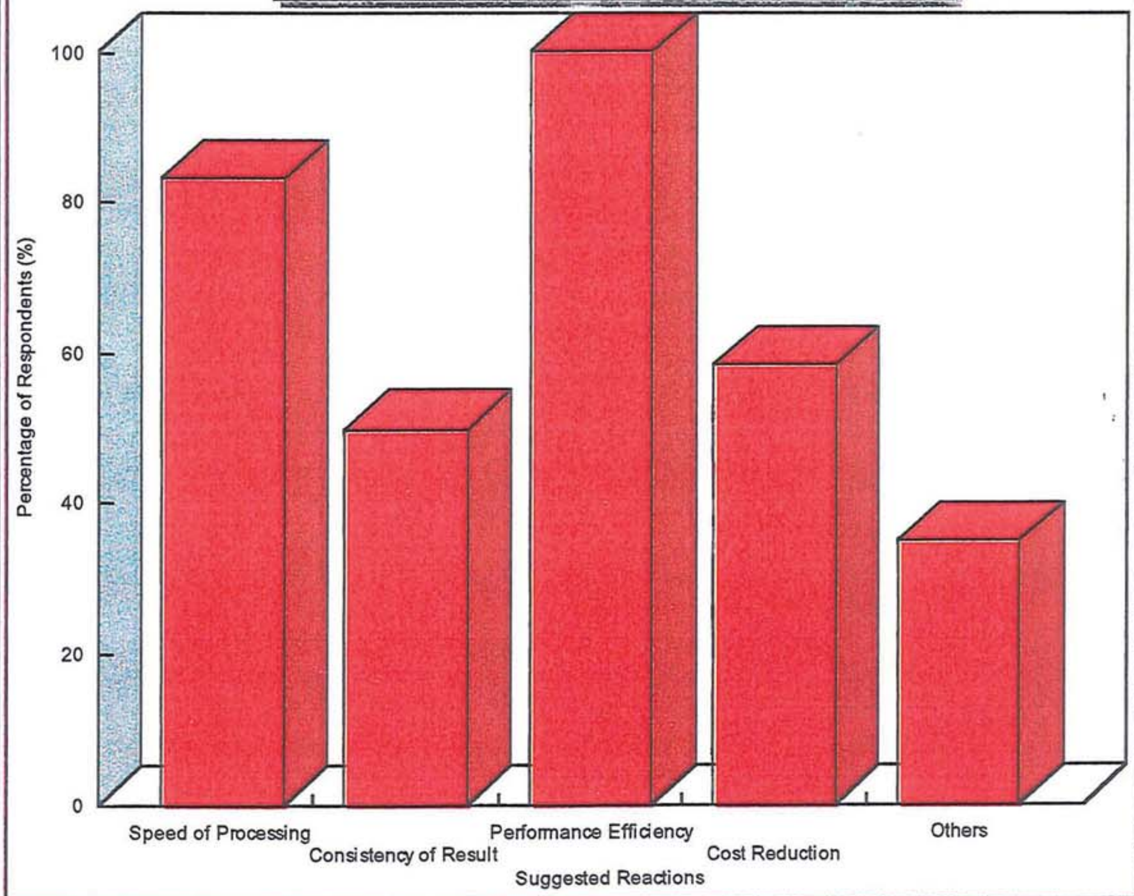
. Performance Efficiency

. Cost Reduction

. Others.

Participants were asked to tick any of the above which applied to them. Their replies are presented in figure 8.3 below.

Figure 8.3 Potential Achievements



All the respondents hoped that the system would help them to achieve Performance Efficiency. 83% believed that the system will provide fast processing capabilities, while 50% agreed that the system will provide consistent results. The idea that the system would help to achieve cost reduction won 58% support from the respondents. See figure 8.3 in page 206.

Question six was designed to capture the reactions of people in the purchasing and supply function towards using expert system programs in solving the problem of vendor selection. Four possible reactions were listed:

. Hostile

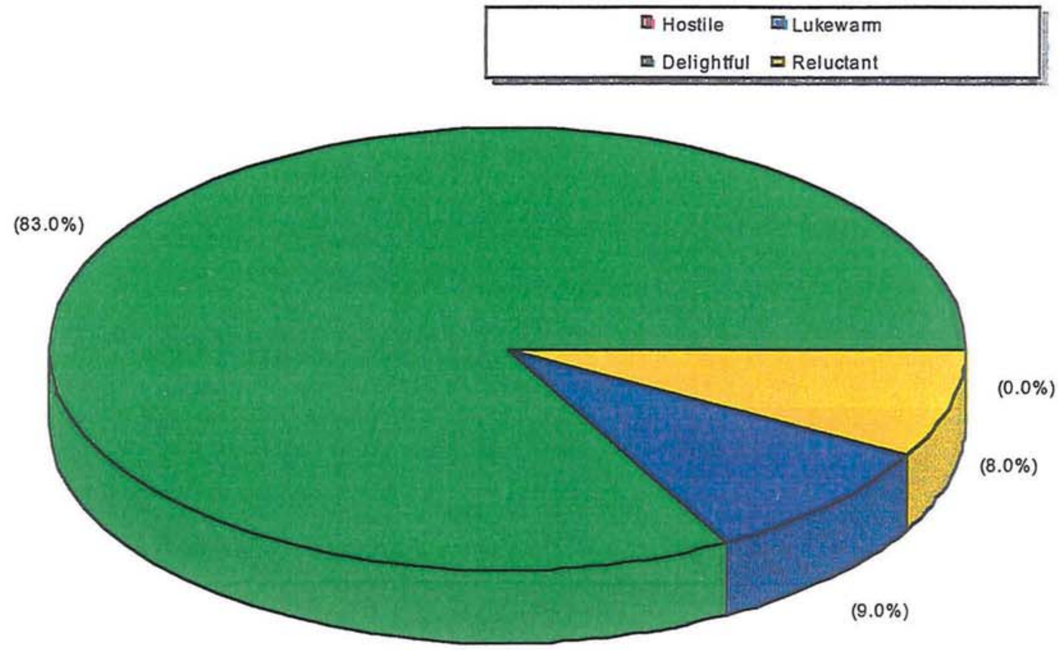
. Delightful

. Lukewarm

. Reluctant.

The respondents were very excited while testing the prototype, and after running the tests, they admitted that they had never seen anything like it before. Their responses to the above question are shown in the form of a pie chart in figure 8.4 in page 208 overleaf.

Figure 8.4 Reaction towards the System by Organisations



None of the organisations approached had come in contact with any Expert Systems before, never mind one that determines vendors' financial background. When asked to describe the reaction of their organisation towards using ESfVS, 83% of the respondents said they would be delighted to use the program. 8% would be reluctant to use it and another nine percent admitted they would be lukewarm whereas no one confessed that they would be hostile to using the system. Figure 8.4 above shows the percentages of the reactions of organisations towards using expert systems for solving vendor selection problems.

At present only 8% of the respondents said they normally inquire about the financial background of their potential suppliers. The other 92% do not. They all agreed, however, that establishing some standard means of determining the financial background of a prospective vendor would be warmly welcomed.

When they were asked about their awareness of financial ratios in question 8, in order to confirm that they understood the ratios, their answers were very revealing. Their level of familiarity with financial ratios is shown below. The respondents were more familiar with Profit Ratio than any other financial ratios, as table 8.3 indicates. This is followed by the Borrowing Percentage.

Table 8.3.

RATIOS	Familiarity Level(%)
Current Ratio	58.33
Quick Ratio	58.33
Borrowing Percentage	75.00
Profit Ratio	83.33

The familiarity level with Current and Quick Ratios of 58% for each were actually less than expected.

The respondents saw the prototype system as a user friendly program which, they admitted, helped them to understand the difference(s) between expert systems and other computer programs.

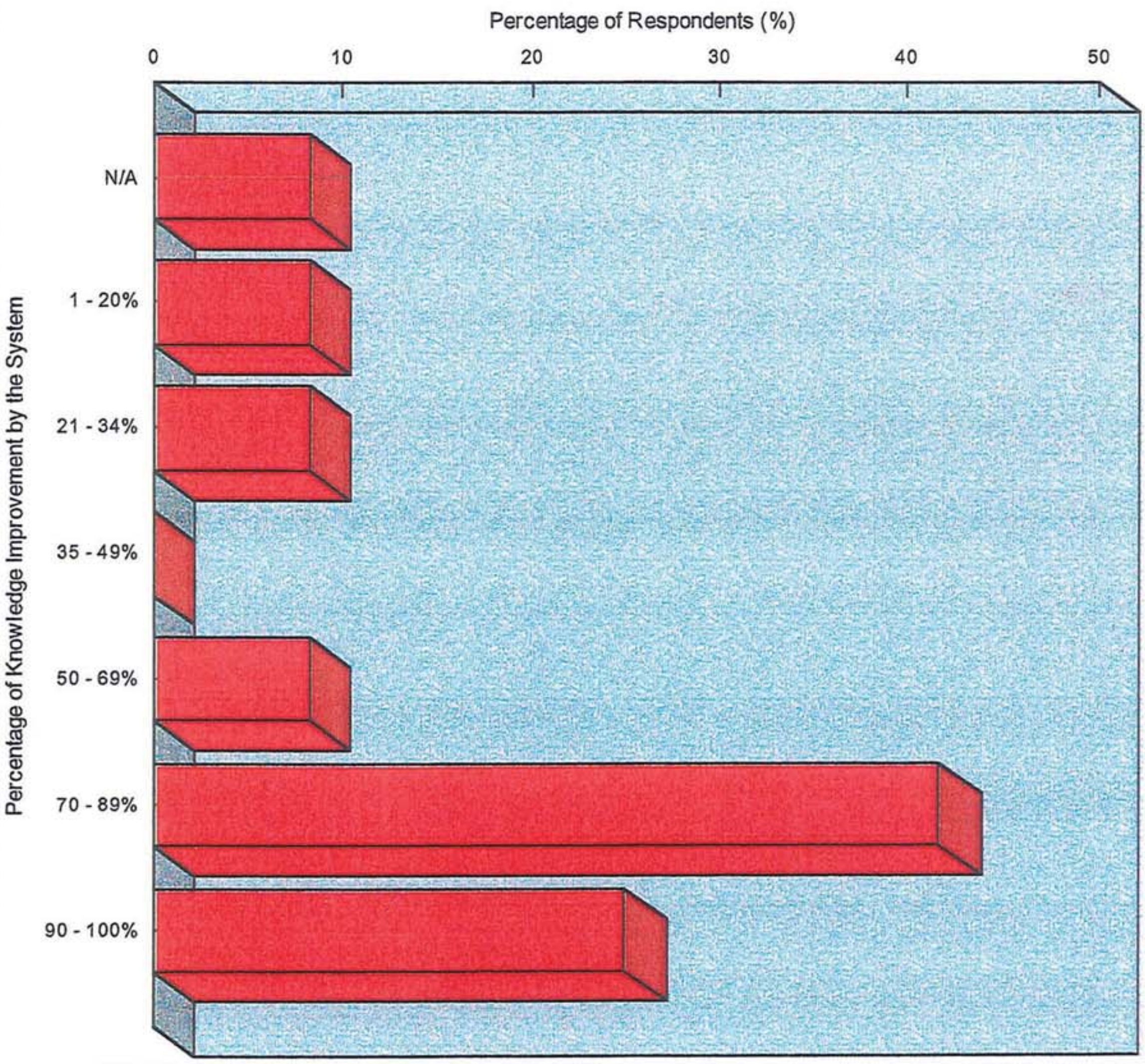
In question 13, the respondents were asked to disclose the extent to which the system improved their knowledge of expert systems. A range of percentages were provided so that they would tick whichever that applied to their case. The ranges of these percentages are:

. 90 - 100 [ ] . 70 - 89 [ ] . 50 - 69 [ ] . 35 - 49 [ ]

. 20 - 34 [ ] . 1 - 20 [ ] . Not at All [ ]

The way they responded to the above is presented in figure 8.5 below.

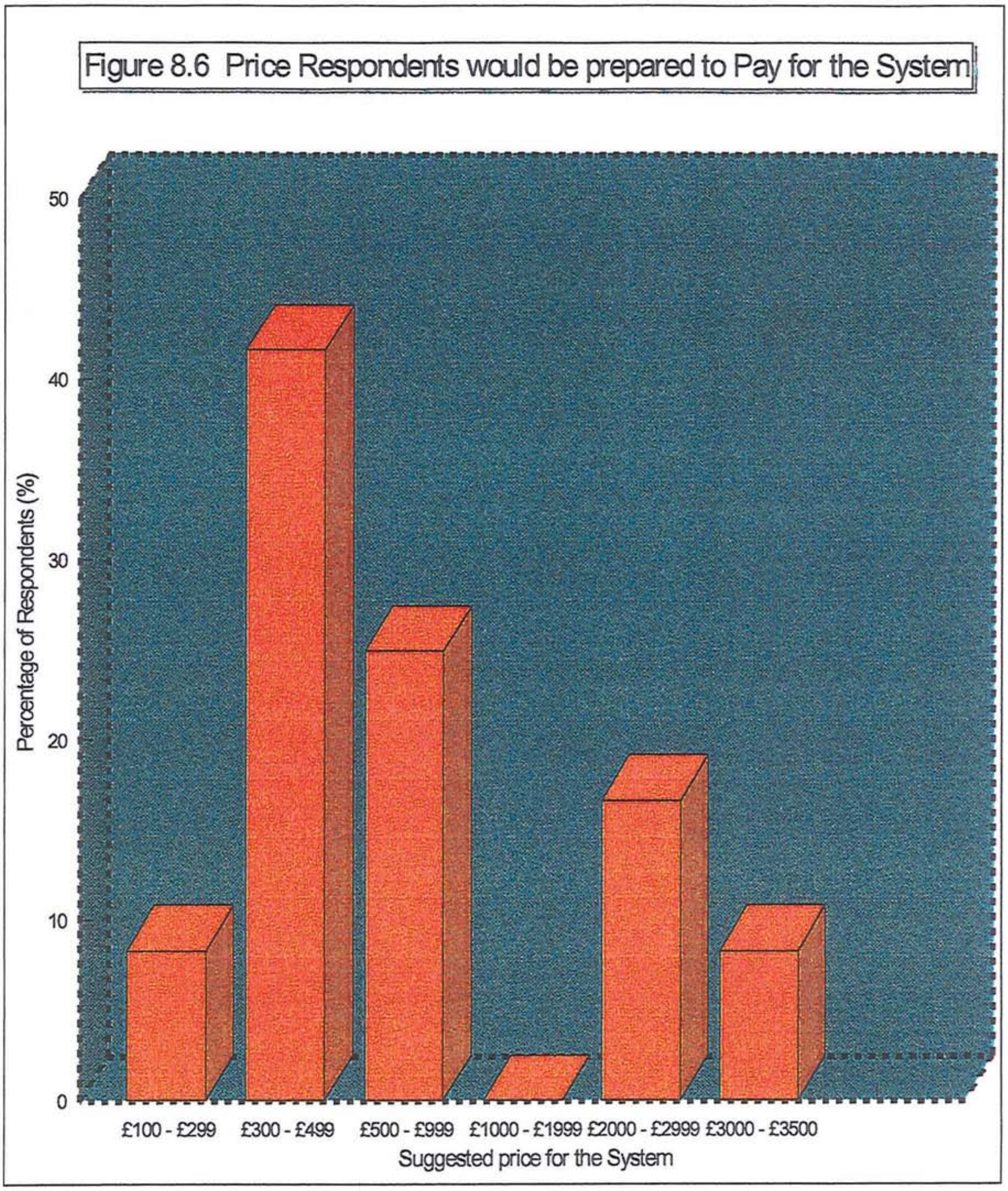
Figure 8.5 Improvement in the knowledge of E. S.



Ten percent of the respondents said the system did not improve their knowledge of expert systems. Another 10% admitted that their knowledge of expert systems was improved by between 1 and 20%. A further 10% of them improved their knowledge of the subject by between 21 and 34%, see figure 8.5. A revelation that more than 40% of the respondents admitted that the system had contributed to increase in their knowledge of the subject by almost 80%. Little under 30% agreed that their knowledge of the subject improved by 95%.

The belief that the system generated some awareness and increase in the knowledge of Expert Systems as demonstrated in figure 8.5 was very much appreciated. It is fulfilling to acknowledge the fact that the system had made a positive contribution towards extending the frontier of knowledge in the domain of Expert Systems (A/I).

To assess the commercial viability of the system, the respondents were asked to reveal how much money they would be prepared to pay for the system. Some amounts of money were suggested as a guide to enable them put forward how much they would want to pay for a system that could perform their functions. The results are presented in figure 8.6 overleaf.



As figure 8.6 above demonstrates, more than forty percent of the respondents said they would be prepared to pay between £300 and £499. Twenty five percent were willing to pay £2000 or more. These results suggest that expert systems in this application domain have good commercial potential.

9. CONCLUSIONS AND FURTHER WORK

The research programme has helped to expose one of the biggest problems which confronts those responsible for procuring materials used in organisations. The problem is determining a reliable source(s) of supply. Establishing a source(s) that would not disappoint, as disappointment could mean closing down an entire business organisation, requires a great deal of effort, Paulden (1977).

An investigation into how organisations solved the problem(s) revealed that there were twenty different factors which those who perform the task considered during the process of selecting a suitable and reliable vendor(s). These factors were listed in table 5.2 and discussed in pages 115 and 116. The respondent organisations agreed that three of those twenty factors were more important than any other. The three factors are; Product Price, Product Quality, and Delivery Dates.

Further analysis of the acquired data suggested that the degree of importance of certain factors depended on the size of the individual organisation in question. That is to say that factors such as Financial

Background and Manufacturing Capacity were awarded much more recognition by bigger organisations than by smaller ones. Further investigations were made to discover whether the type of industry affected the way these factors were regarded. The analysis revealed that no significant differences existed, thus they agreed on the rank order of the factors.

An objective of the research project was to discover whether an expert system program could be used in solving the problem(s) of vendor selection. A literature review was conducted to ascertain whether such a system was in existence. The literature review disclosed that only one published work was available in the subject area. However, expert system programs are in use in other domain applications, eg VATIA, COMMIE, etc, Jackson (1996). It was discovered that there was very little awareness of expert systems and their capabilities within the purchasing and supply functions.

Time constraints and resource limitations did not permit the development of a comprehensive system that would solve the entire problem of vendor selection. Therefore, a prototype expert system (ESfVS) was built to address one of those twenty factors. The prototype was designed to determine whether a potential supplier's financial background is good or not. The prototype helped in providing not only the expertise but also increased the awareness of and interests in expert systems in organisations. See figure 8.5 in page 210 which shows the level of improvement in the knowledge of expert systems in organisations.

9.1 THE VALIDITY

The issues of the validity of the program are discussed under two premises:- the internal and the external.

On the internal premises, the issues concerning how valid the system is, ie in terms of whether it can do what it is designed to do, how reliable are the conclusions and recommendations, how authentic is the knowledge which the system uses to base its judgement, etc., are discussed. Vokurka et al (1996) and Ryan et al (1992) agreed that the internal validity of a program determines whether valid and reliable conclusions can emanate from such a program.

In our system, the knowledge which was represented in the Knowledge Base came from publications from academics and professionals in the subject area. See chapter 7. Another vital source of knowledge came from direct communications with colleagues who have been in the business of purchasing and supply for several years (some for over twenty years) and who have been supportive throughout the research programme, and from those who interpret financial data. For example, a Sheffield based accounting firm (Egemole & Co. Accountants) was consulted on a number of cases for advice, especially on the treatment of the financial ratios.

The system's outputs were tested. Firstly, where calculations (of ratios) were involved, an electronic calculator was used, and then both results were compared. Secondly, given certain conditions, the system would be expected to give corresponding conclusions. Where it failed to provide the relevant conclusions, the designs were modified, again and again until the desired responses were achieved.

The system's recommendations were then compared with the knowledge and experience of the human experts in the domain application. After processing the given data and drawing a conclusion(s), the developer and the systems testers used their knowledge and expertise to verify whether the system was right or wrong. However, it is not recommended that this should happen whenever the system draws a conclusion, otherwise it would not be cost effective to keep both systems (ie the human and the program) performing the same task. Using his knowledge and experience, the human expert should conduct this reliability check a few times and once it is certified that the systems results are correct, reliable and consistent, then the system should be allowed to run. The prototype was tested many times in-house (see table 8.1) and then certified valid before it went for more rigorous tests by people in other organisations.

On the external premises, the issues concerning the research findings are assessed. Thus Blalock et al (1968) argue that where there was low external validity, it would be very difficult to generalise findings to situations in which the variation was not identical. More discussions on this issue are contained in chapter 4 under experimental research approach. However, at this point, one might wonder whether twelve test trials would be enough on which to base the assumption that the program was widely accepted by organisations. The question at this point was "how many tests would be adequate?". We could go on and on until infinity, but the resources at our disposal and the time allocated for the research determined how far we were able to go.

Therefore, the validity of the research results was based on the consistency of answers from the twelve organisations rather than on conducting more test trials. All the respondents agreed that, for example, the system would improve performance efficiency within their organisations, more than ninety percent of them confirmed that their knowledge of expert systems was improved. Eighty three percent of the respondents said they would be delighted to use the system if it were developed. Also, they all agreed that the system was worth a lot of money, and agreed to pay an average of more than £600 for the system.

To sum up therefore, an expert system is a tool which has proven that it can be used to solve domain specific problems. It deals with defined problems the way a human expert would. It has many advantages over the use of a human expert or other conventional computer programs for solving domain specific problems. Lack of appropriate knowledge of the technology and its capabilities has proved to be a major handicap to selling expert systems products. Out there, expert systems have commercial viability if, and only if, people are made aware of the technology and its benefits.

9.2 FURTHER WORK

The research project identified twenty factors which those in the purchasing and supply function consider during the process of vendor selection. The project went further to develop a prototype of an expert systems program that addressed one of the factors ie. the Financial Background of a potential supplier(s). In order to have a comprehensive program which could address the entire problem of vendor selection, the twenty factors will have to be developed.

Further work should therefore focus on developing these remaining factors, perhaps one factor at a time, until the full system is built.

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11. APPENDIX

Appendix 1.

First Set of Questionnaires and its covering Letter. p. 232 - 238

Appendix 1B

Scatter Diagrams of the way the Ranks were awarded to the 20 Factors by the respondent organisations. P. 239 - 258

Appendix 2.

The Ranks awarded to the factors under examination by different sizes of the respondent organisations. P. 259 - 263

The Ranks awarded by different types of industries to the factors under examination. P. 264 - 268

Analysis Using Kruskal Wallis One-Way Analysis of Variance by Rank (H) to determine if differences existed in the way that the following factors were ranked by different sizes of the organisations:

FNCE
CPST
REPS. P. 269 - 271

Appendix 3.

Analysis Using Kruskal Wallis One-Way Analysis of Variance by Rank (H) to determine how different types of organisations regard the variable factors. All the twenty factors were assessed individually: p. 272 - 291.

Appendix 4.

Analysis to determine whether differences existed between the ranked factors as regarded by different types of organisations, Using Friedman's Two-Way Analysis of Variance by Ranks (Xr^2): p. 292.

Appendix 5.

Analysis Using Kendall's Coefficient of Concordance (W) to establish whether there was some form of agreement about how the respondent organisations regarded the ranked factors: p 293.

Appendix 6.

The Rule List. That's the Expert Systems Program as represented by the system: P. 294 - 307.

How to Run the Test Program. P. 308

Appendix 7.

The Second Set of The Questionnaires and the covering Letter: p. 309 - 311.

EXPERT SYSTEMS FOR VENDOR SELECTION

THE SURVEY QUESTIONNAIRE

PURPOSE OF THE SURVEY:

The problem(s) of selecting the vendor(s) who can and will supply the required material input is a major issue that confronts those responsible for procuring materials for manufacturing firms.

The purpose of this survey is to:

- make contacts with people in the industries who may be involved in further works concerning the development of an expert systems program for vendor selection.
- ascertain the general idea of how companies look at the problem(s) of vendor selection.
- assess the awareness of Expert Systems technologies within the purchasing organisations.
- find out if there is any form of commonality in the way that the vendor selection problem is tackled

The collected data will be used as part of a research programme into building an Expert Systems Program which organisations can use for supplier selection. The respondent is therefore required to be as sincere and as precise as possible in completing the form so as to enhance the accuracy and the validity of the programme results.

Every piece of information that is supplied by a respondent will be used for the purpose of this research programme only. No part of the data will be disclosed to other organisation(s) or to other interested person(s) without the prior consent of the respondent.

Are you the person who selects the vendor(s) that supplies raw materials to your organisation?

Please circle the correct answer: YES NO

If the answer is NO then the person(s) who performs the vendor selection tasks should complete the form.

NAME & ADDRESS OF YOUR ORGANISATION

____

____

NAME OF RESPONDENT

____

POSITION IN ORGANISATION

____

1). How many employees are there in your organisation?
Please circle the appropriate number:

1).	1 - 20
2).	21 - 50
3).	51 - 100
4).	101 - 200
5).	201 - 350
6).	351 - 500
7).	501 - 1000
8).	1001 - 2500
9).	2501 - 5000
10).	5001 - 10000
11).	> 10000

2). How many employees actually perform the vendor selection tasks?

1).	1
2).	2 - 3
3).	4 - 6
4).	7 - 12
5).	13 - 20
6).	21 - 35
7).	36 - 60
8).	61 - 100
9).	101 - 350
10).	> 350

3). Which of the following factors do you consider in the process of selecting the vendor(s) and in what order of importance would you number them?

- product price ______
- product quality ______
- delivery dates ______
- production method ______
- financial background ______
- manufacturing capacity ______
- management efficiency ______
- technical competence ______
- similarity in the technology used ______
- size of the organisation ______
- geographical location ______
- position in the industry ______
- conduct of the sales rep. ______
- honesty ______
- after sales / backup services ______
- recommendations from associates or friends ______
- loyalty to friends or relatives ______
- ability to provide sufficient information about their product(s) and organisation ______
- listed in the business directories ______
- their interest in your product(s) ______

If there are other factors which are not listed above, could you please name them and number them accordingly.

______

______

______

______

______

4). How do you choose a suitable price:

- by comparing prices from different suppliers and then choosing the lowest price?

  YES NO

- by fixing the price that you are willing to pay for an item and then choosing the one that is nearest to it?

  YES NO

- by some other method? YES NO
  (please explain)

______

______

______

______

______

______

______

______

5). Do you measure the quality of the suppliers' services by using:

. the number of rejects (or defective items) as a ratio of the total delivery?

YES NO

. the number of the items which are delivered as and when agreed as a ratio of the total requisition?

YES NO

. some other method? YES NO
(please explain)

____

6). Do you visit the suppliers' plants in order to assess:

. their manufacturing capacity? YES NO

. their management efficiency? YES NO

. their production method? YES NO

. their technical competence? YES NO

7). How do you measure the manufacturing efficiency of the suppliers' organisation? ______________________________

____

8). Do you collect information regarding the financial background of your suppliers?

YES NO

If the answer is YES, from what source do you obtain it? please specify ______________________________

____

9). Do you use expert system technologies in performing the vendor selection task?

YES NO

If the answer is NO, is it because;

a). you do not think that expert systems can be used for vendor selection?

YES NO

b). of the cost of installing expert system program?

YES NO

c). your organisation has little knowledge of expert system technologies?

YES NO

d). your organisation has no qualified professional in the subject area to spearhead the implementation of the expert system program?

YES NO

e). some other reason? YES NO
(please explain)

____
____
____
____
____
____

If the answer to question 9 is YES,

f). when did you start using the system and in what capacity? ______________________
____
____
____

g). what benefits have you achieved since the system became operational? ______________________
____
____
____
____
____
____
____

h). who developed the system? ______________________
____

10). Do you use expert systems in performing any other purchasing task(s)?

YES NO

If the answer is YES, which purchasing task(s)? ______________________________

____

11). Do you use any other computer technologies in tackling the problem(s) of vendor selection?

YES NO

If the answer is YES, what technology? ______________________________

____

____

____

____

____

12). Have you ever thought about using expert system technologies to tackle the problem(s) of vendor selection?

YES NO

If the answer is YES, how far did you go or have you gone to develop the idea?

____

____

____

____

____

____

13). If an expert systems program that performs the vendor selection tasks is developed, will you use it?

YES NO

If the answer is YES, what benefit(s) would you hope to achieve by using the program? ______________________________

____

____

____

____

____

____

If the answer is NO, why would you not use the program?

____

____

____

____

____

____

APPENDIX 1B

Figure 5.4. RANKS FOR THE PRIZ VARIABLE

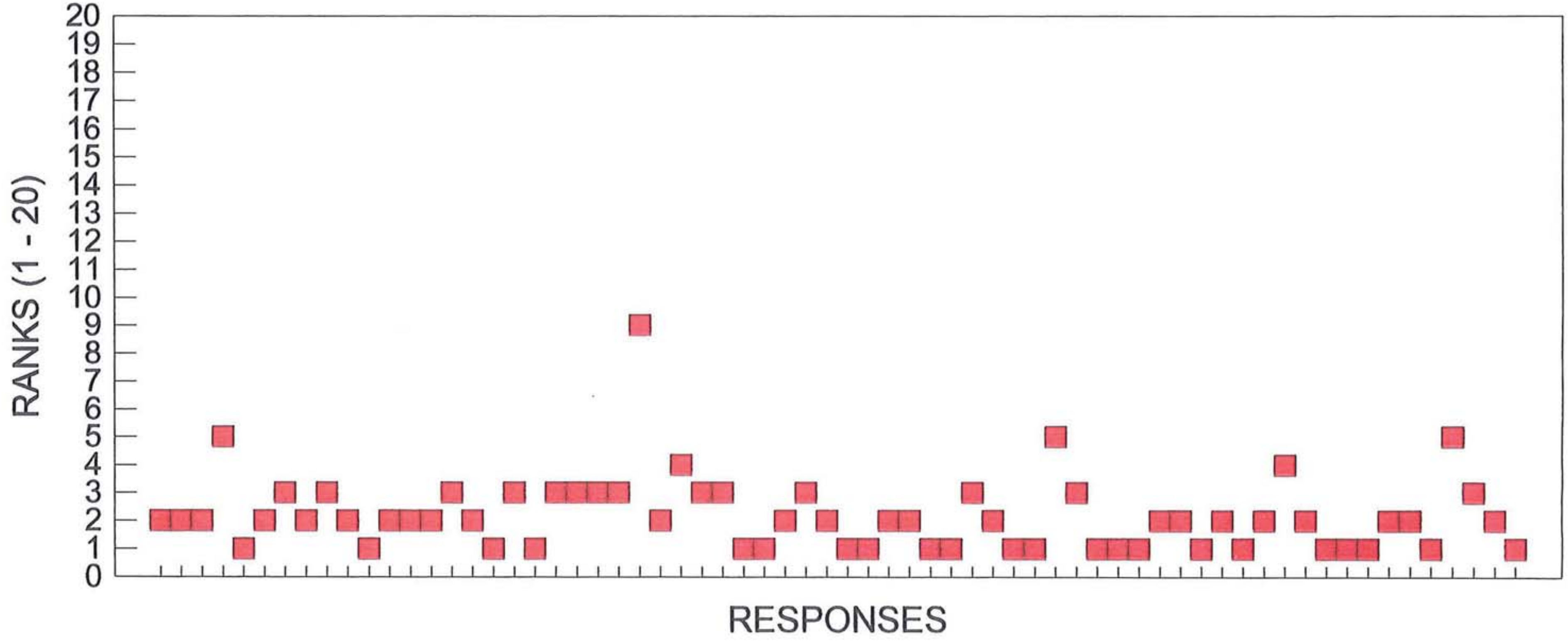


Figure 5.5.

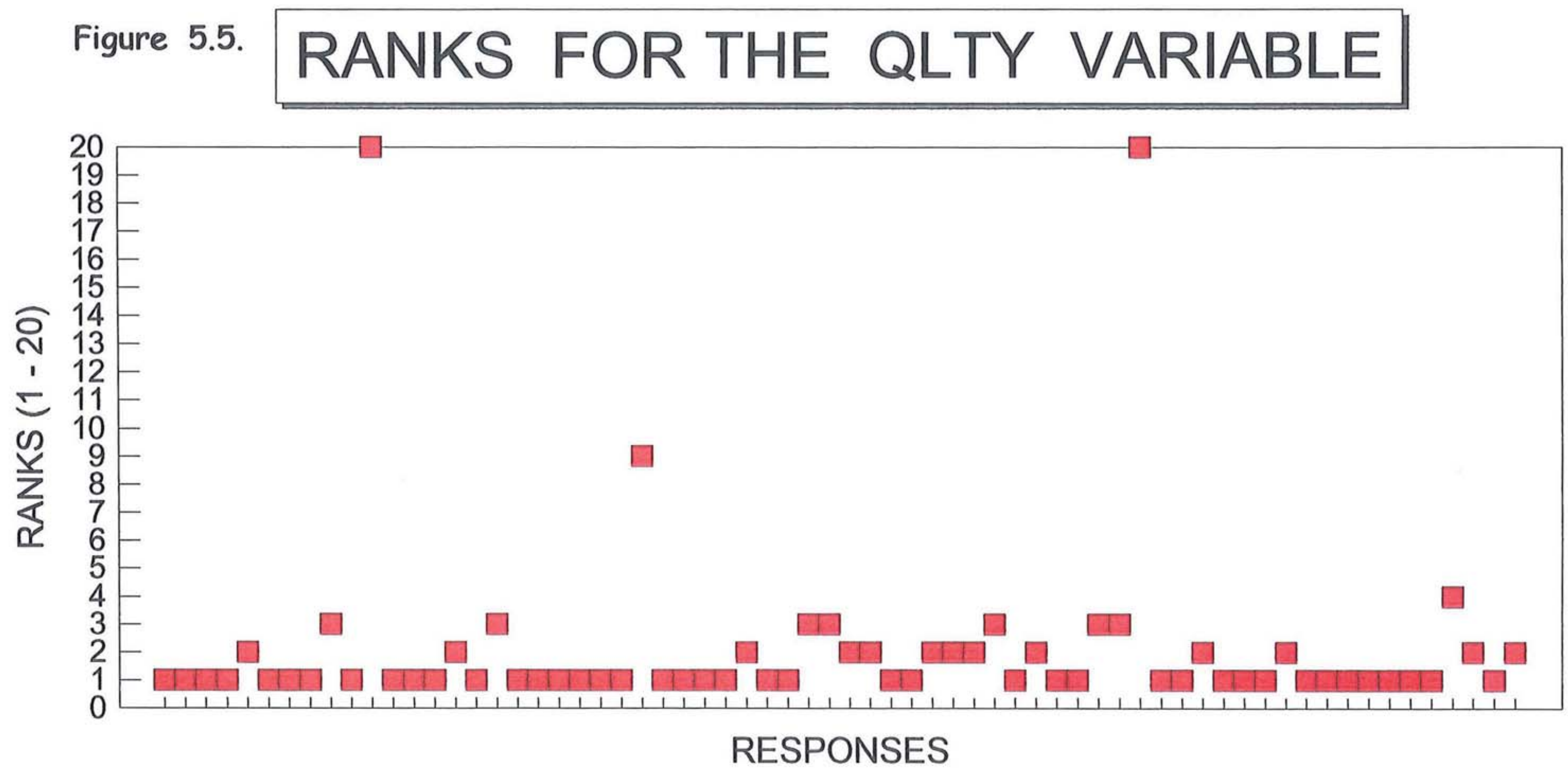

RANKS FOR THE QLTY VARIABLE
RANKS (1 - 20)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
RESPONSES

Figure 5.6. RANKS FOR THE DDTE VARIABLE

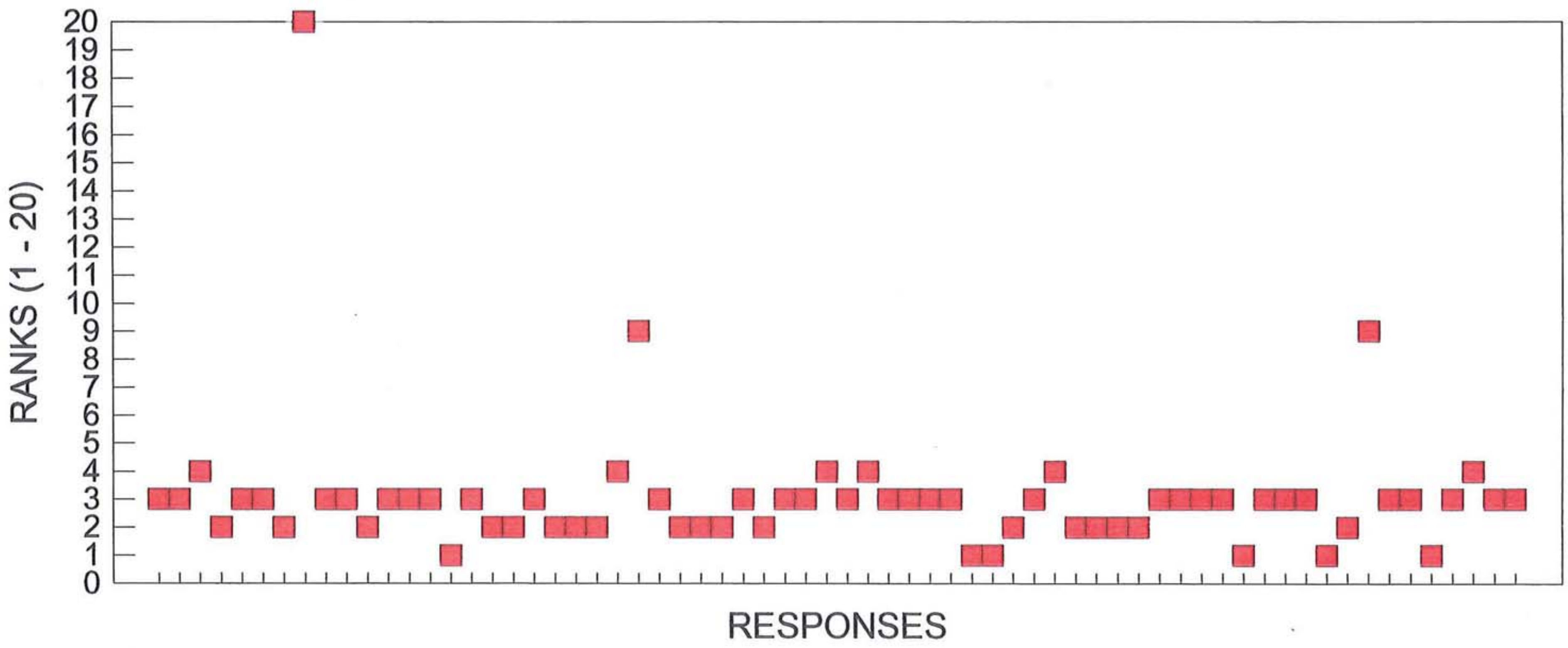


Figure 5.7. RANKS FOR THE MTOD VARIABLE

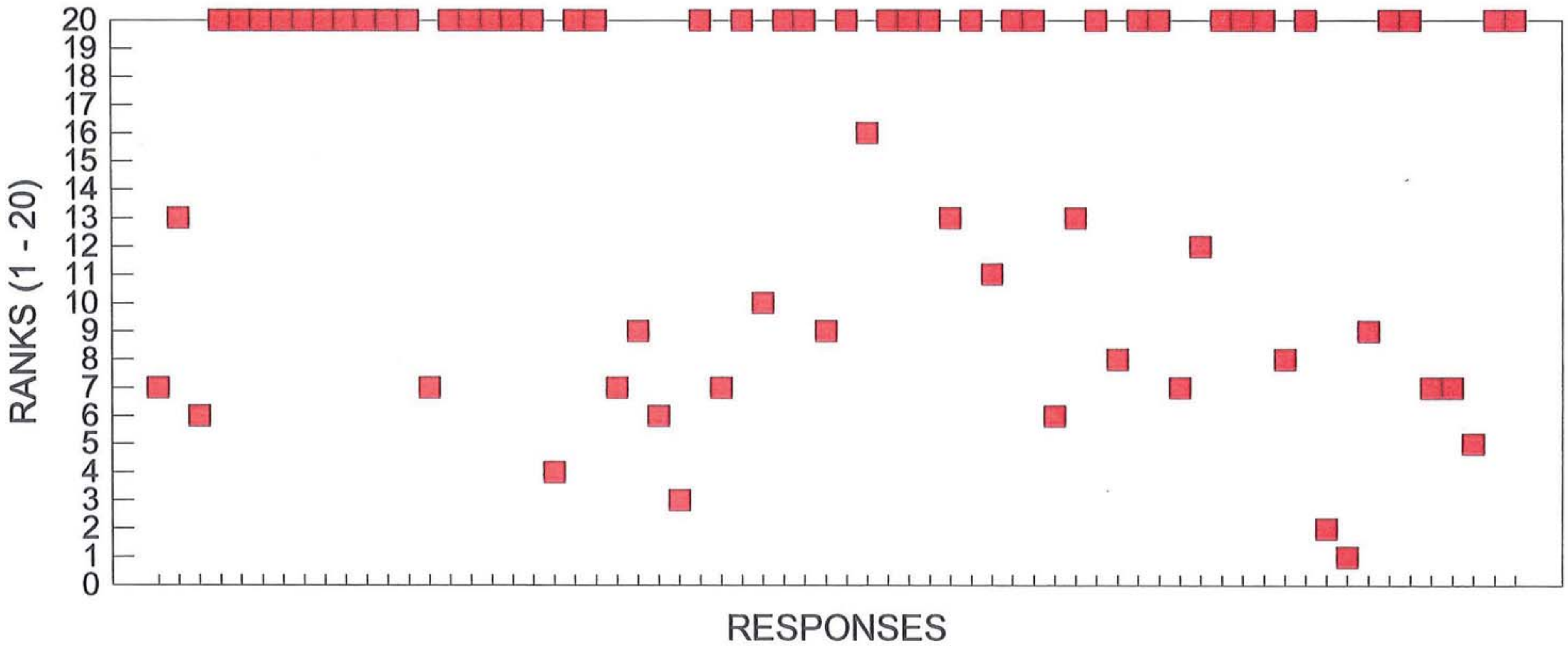


Figure 5.8.

RANKS FOR THE FNCE VARIABLE

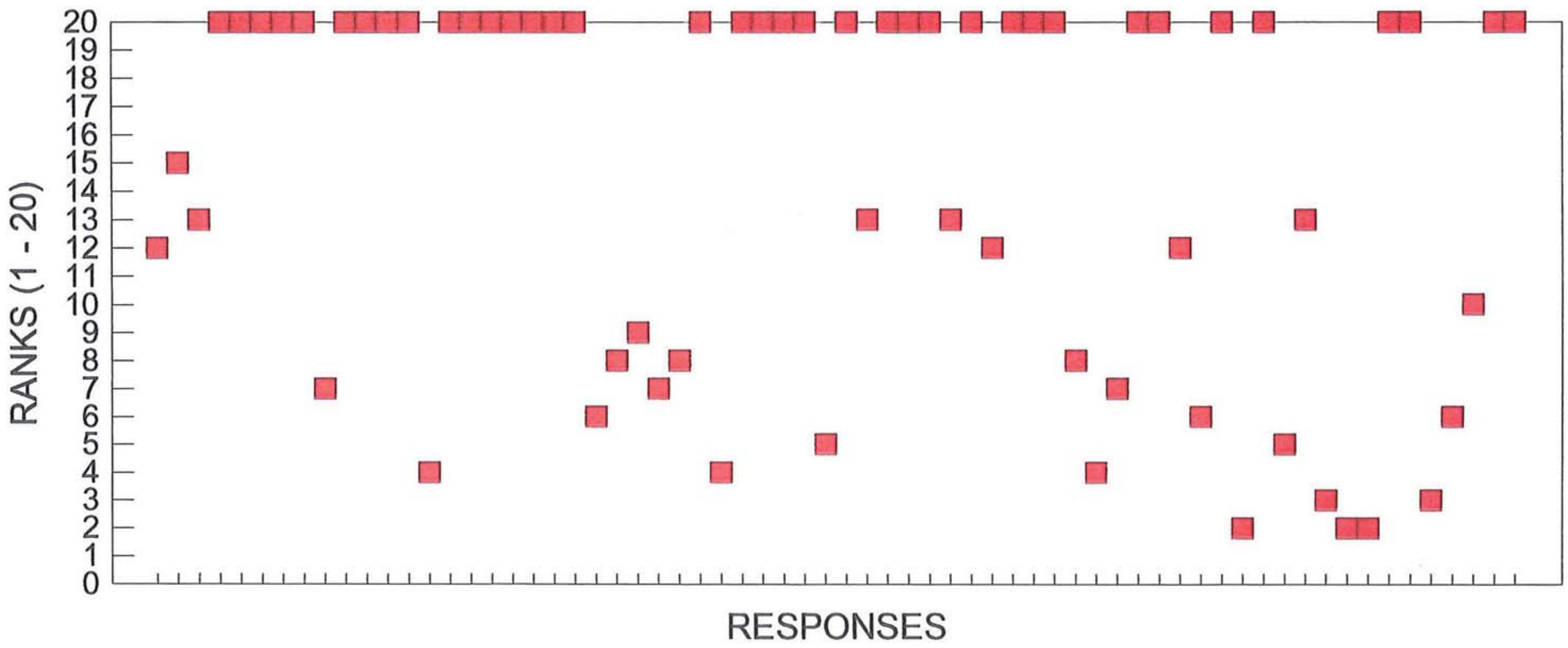


Figure 5.9. RANKS FOR THE CPST VARIABLE

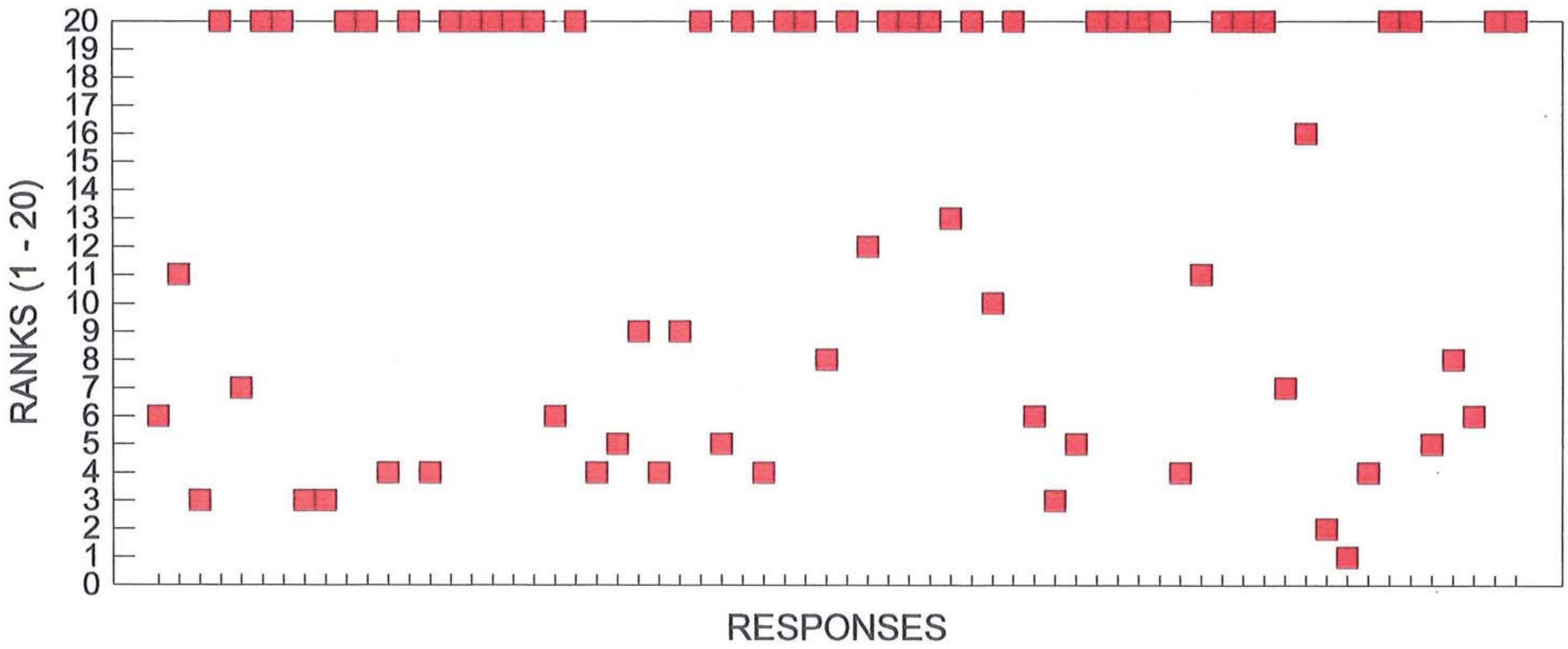


Figure 5.10. RANKS FOR THE MGTE VARIABLE

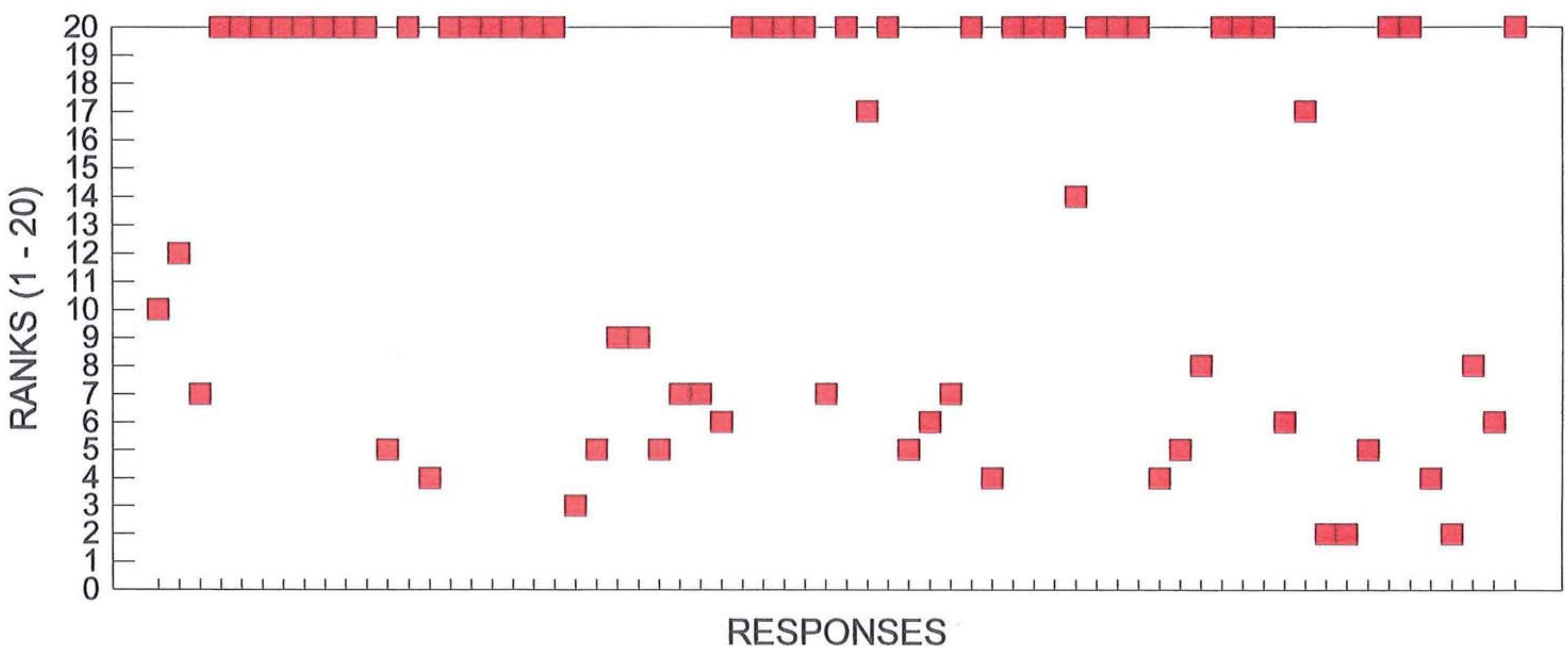


Figure 5.11. RANKS FOR THE TKCE VARIABLE

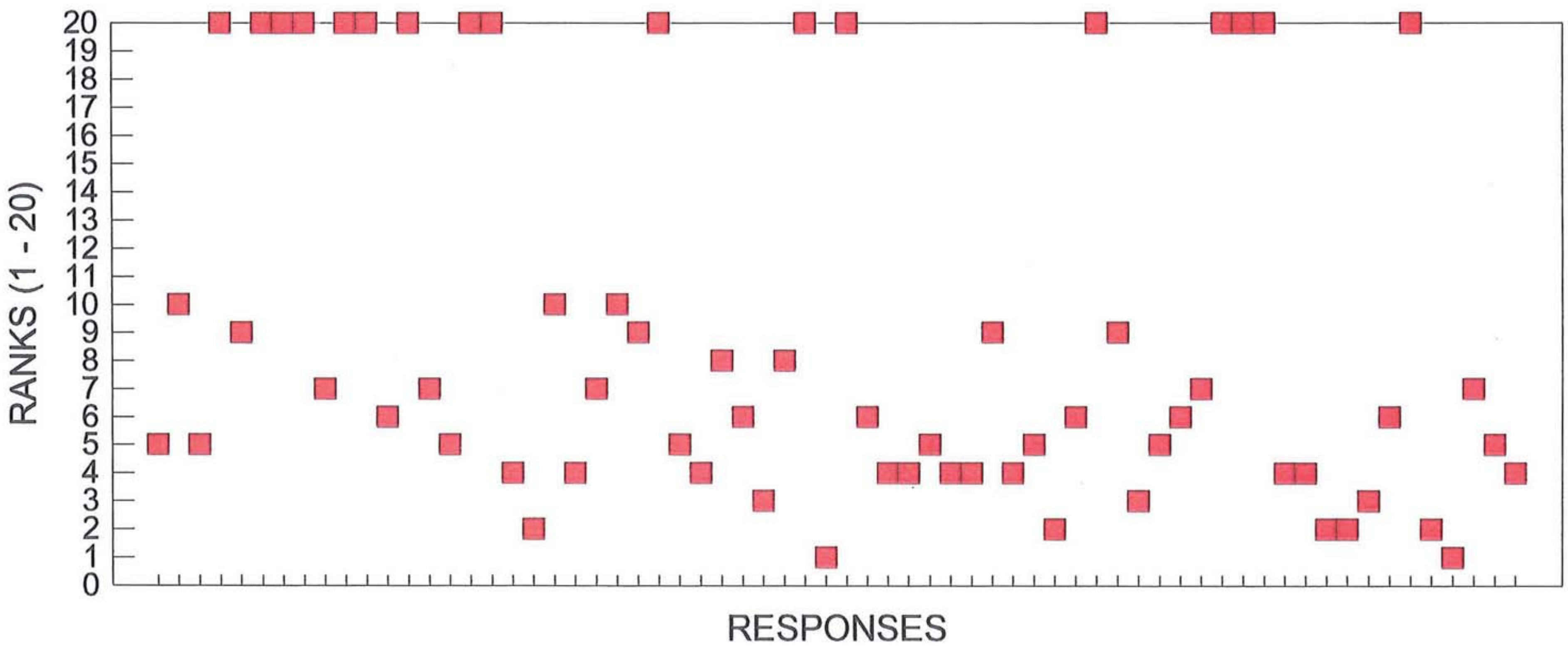


Figure 5.12.

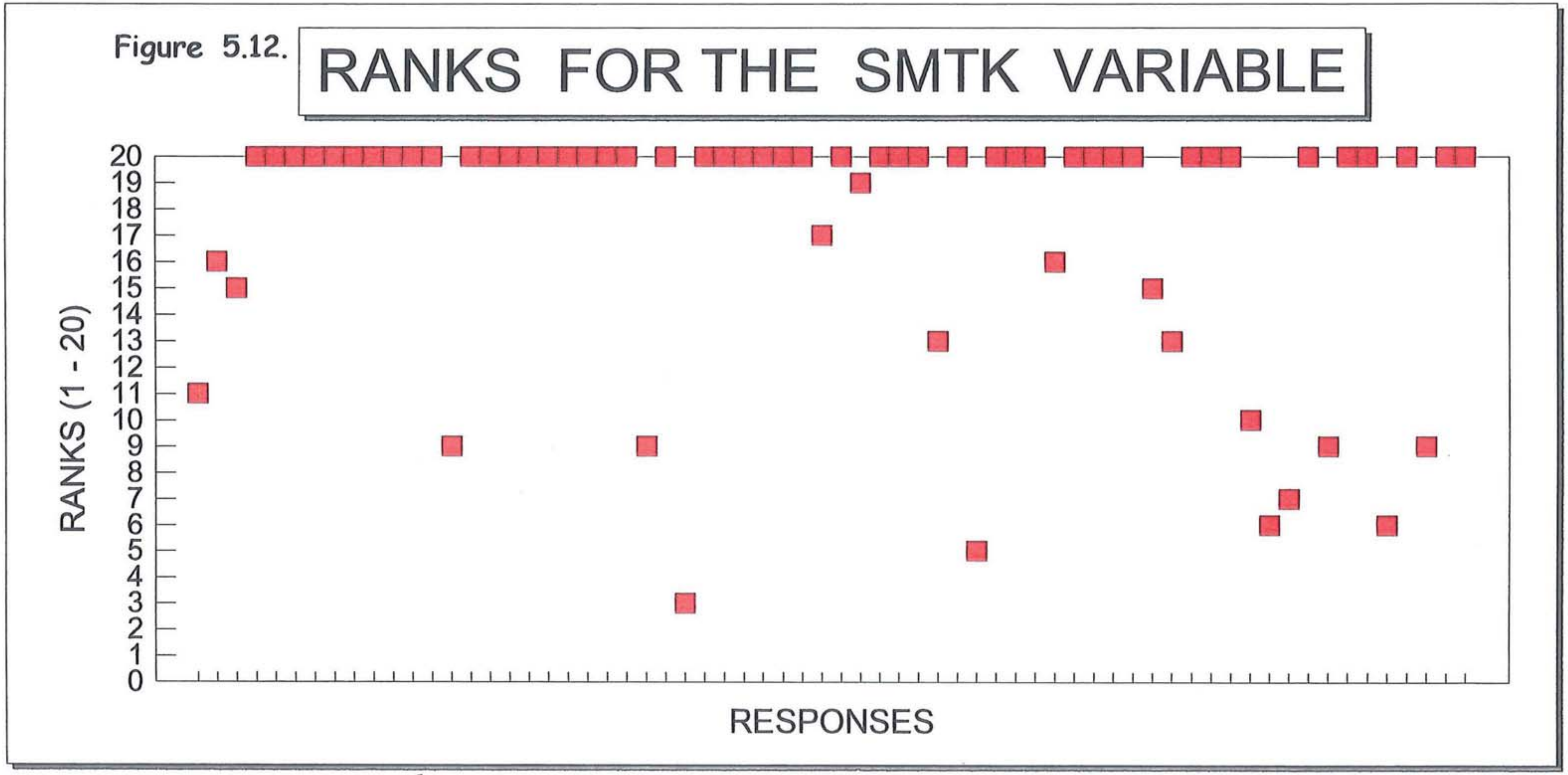

RANKS FOR THE SMTK VARIABLE
RANKS (1 - 20)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
RESPONSES

Figure 5.13.

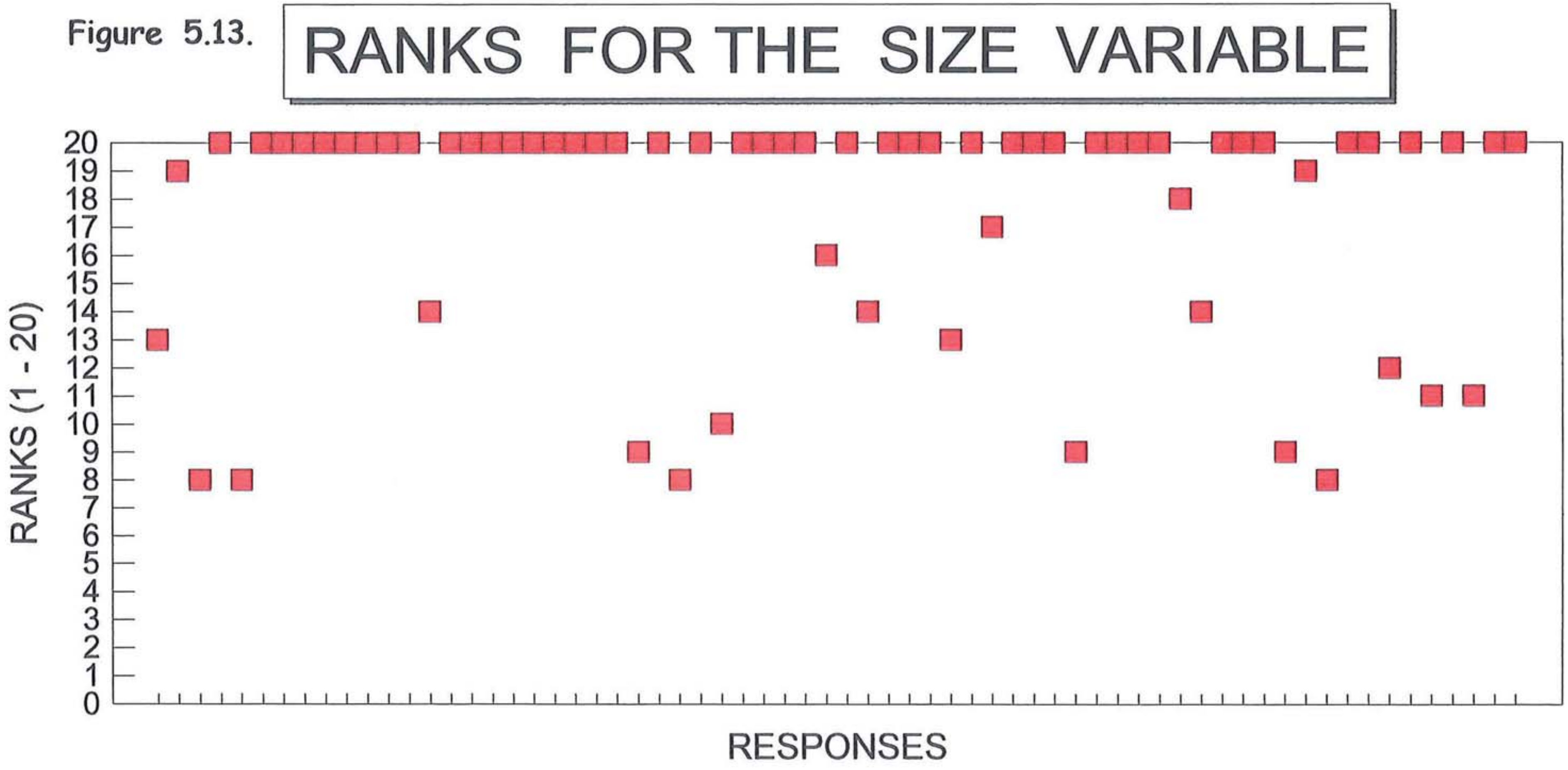

RANKS FOR THE SIZE VARIABLE
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
RANKS (1 - 20)
RESPONSES

Figure 5.14. RANKS FOR THE GOLK VARIABLE

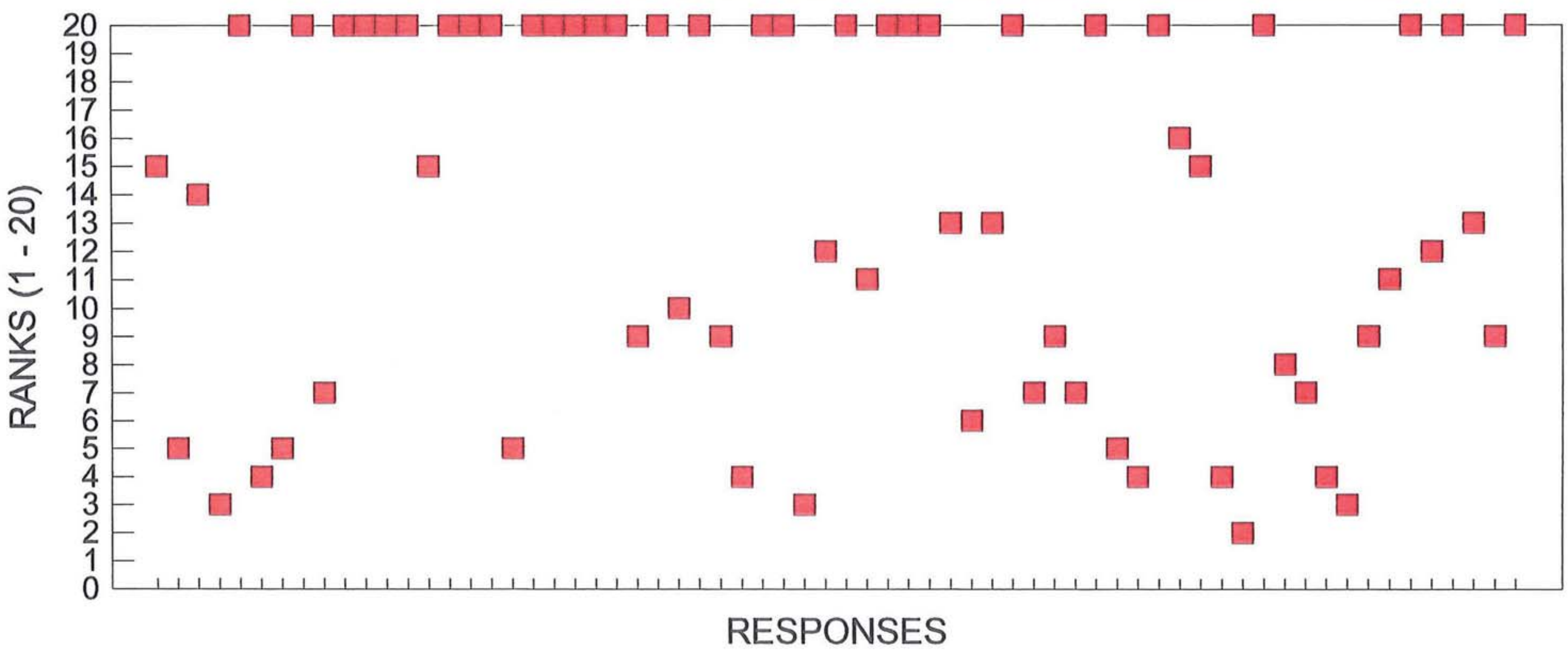


Figure 5.15. RANKS FOR THE PIND VARIABLE

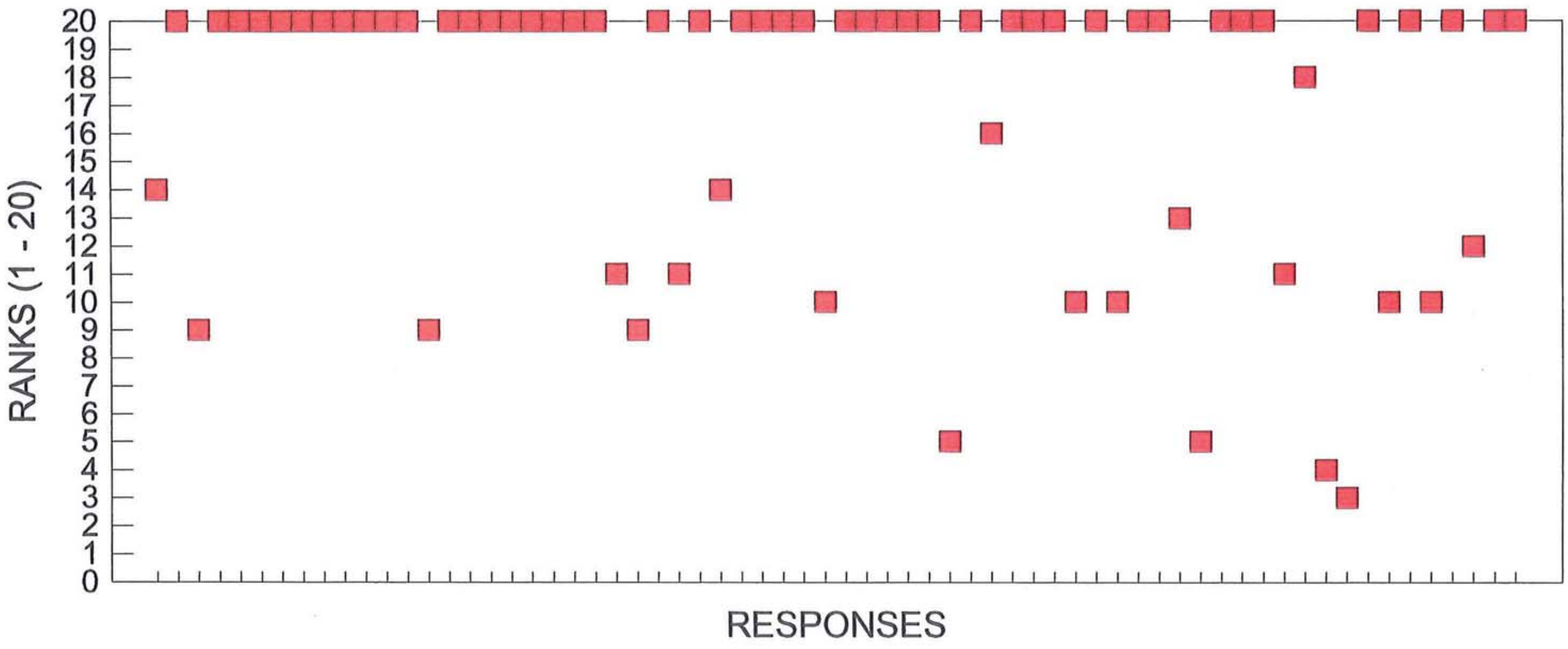


Figure 5.16.

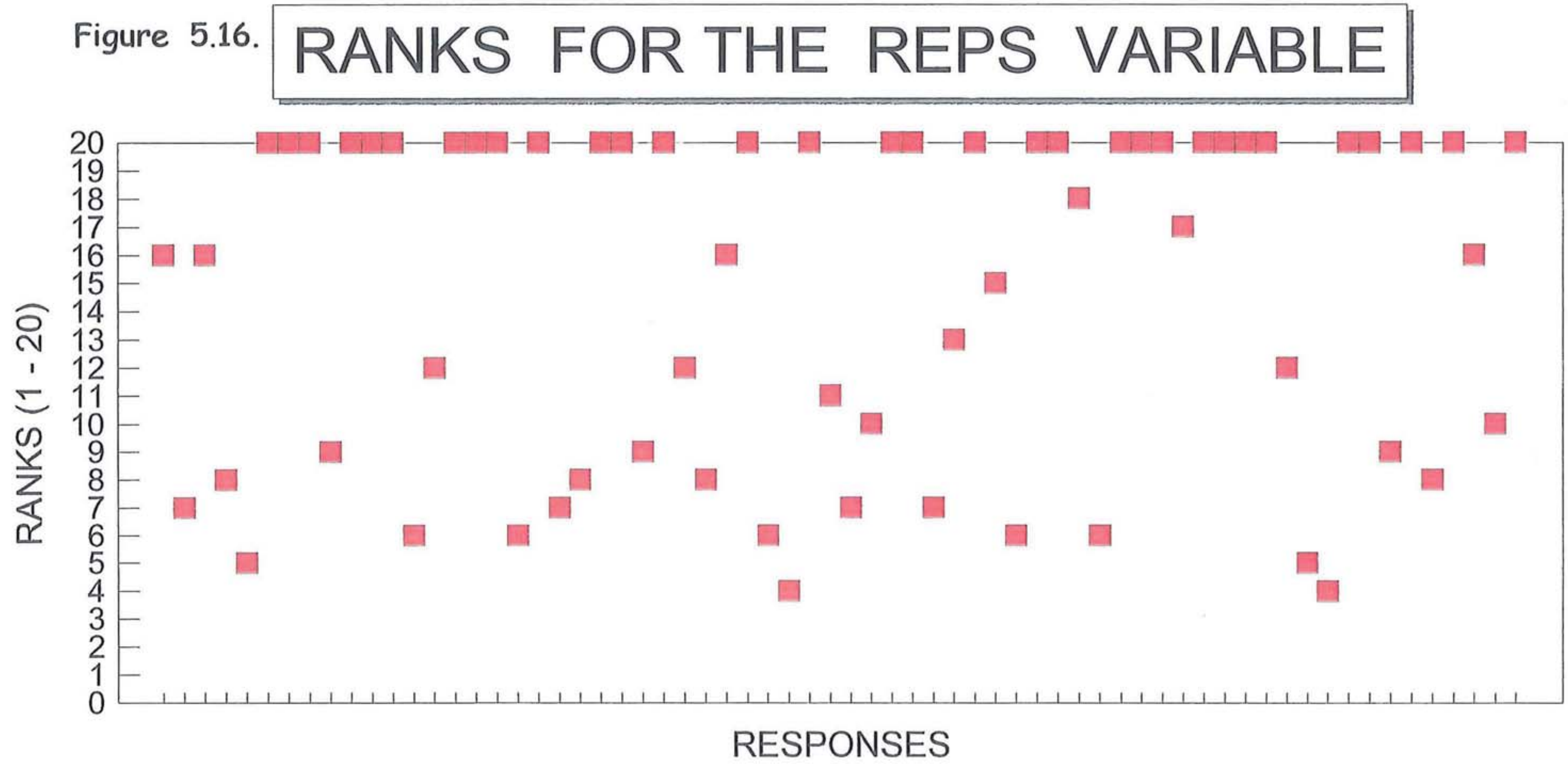

RANKS FOR THE REPS VARIABLE
RANKS (1 - 20)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
RESPONSES

Figure 5.17. RANKS FOR THE HNST VARIABLE

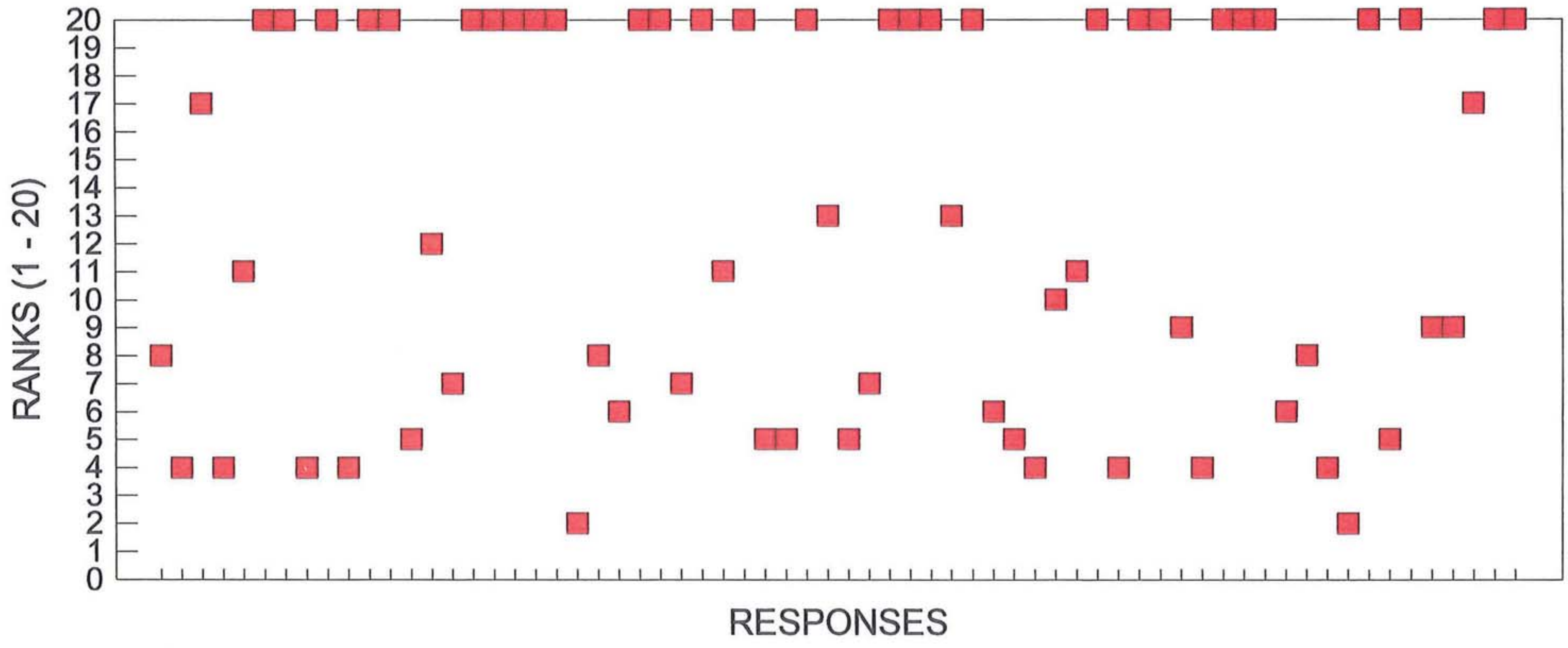


Figure 5.18. RANKS FOR THE BKUP VARIABLE

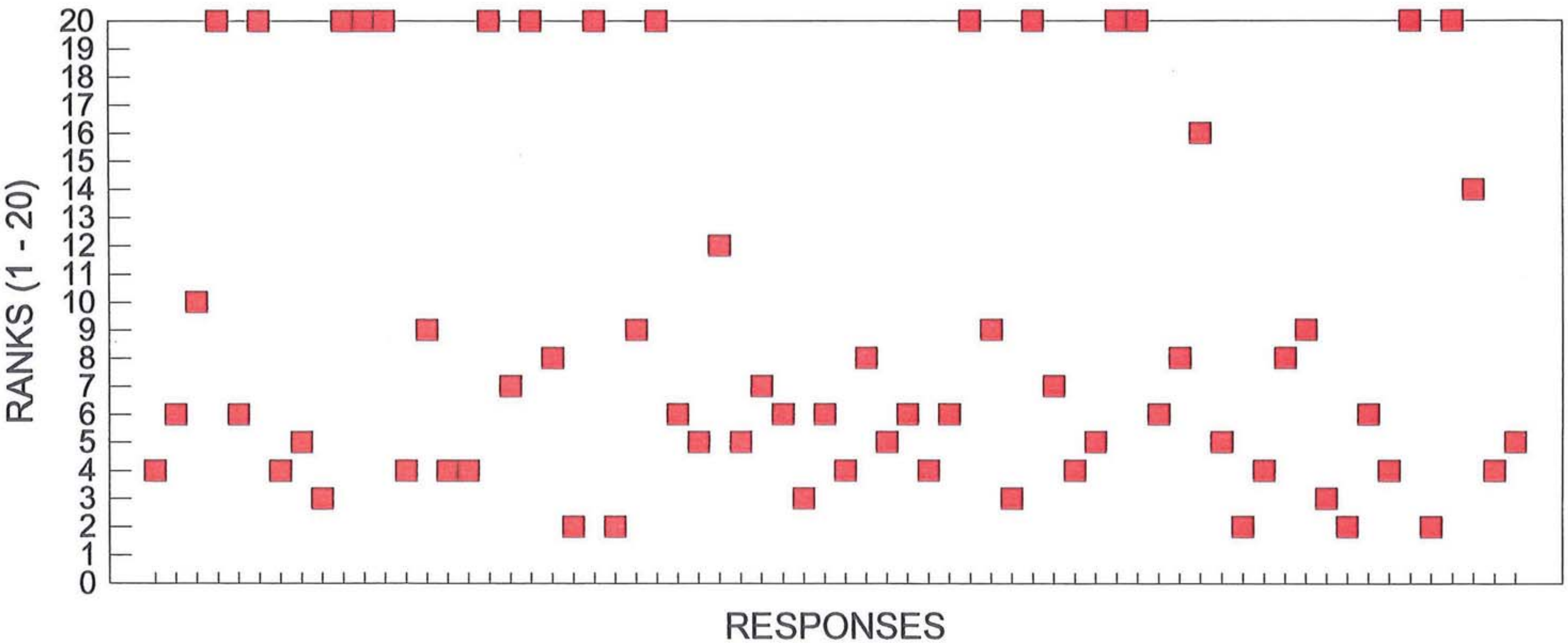


Figure 5.19. RANKS FOR THE RCMN VARIABLE

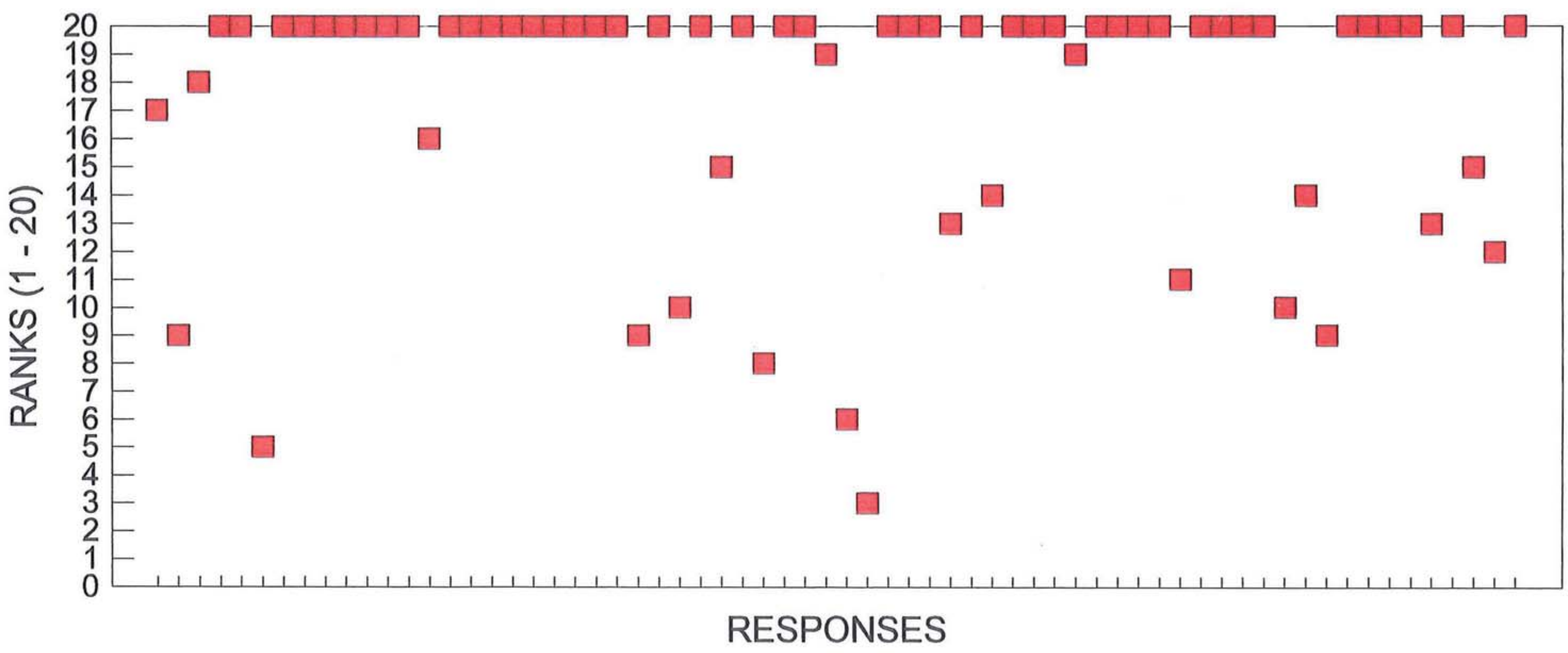


Figure 5.20. RANKS FOR THE LYTY VARIABLE

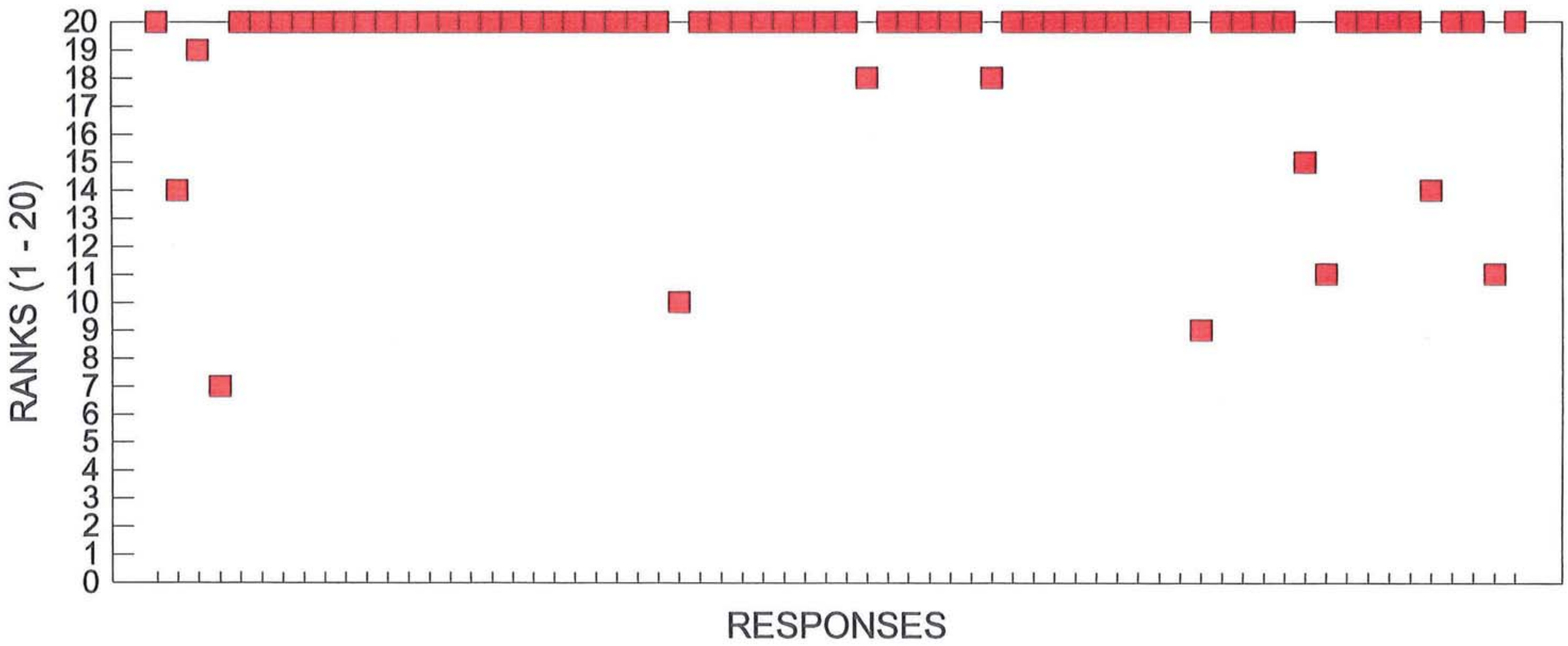
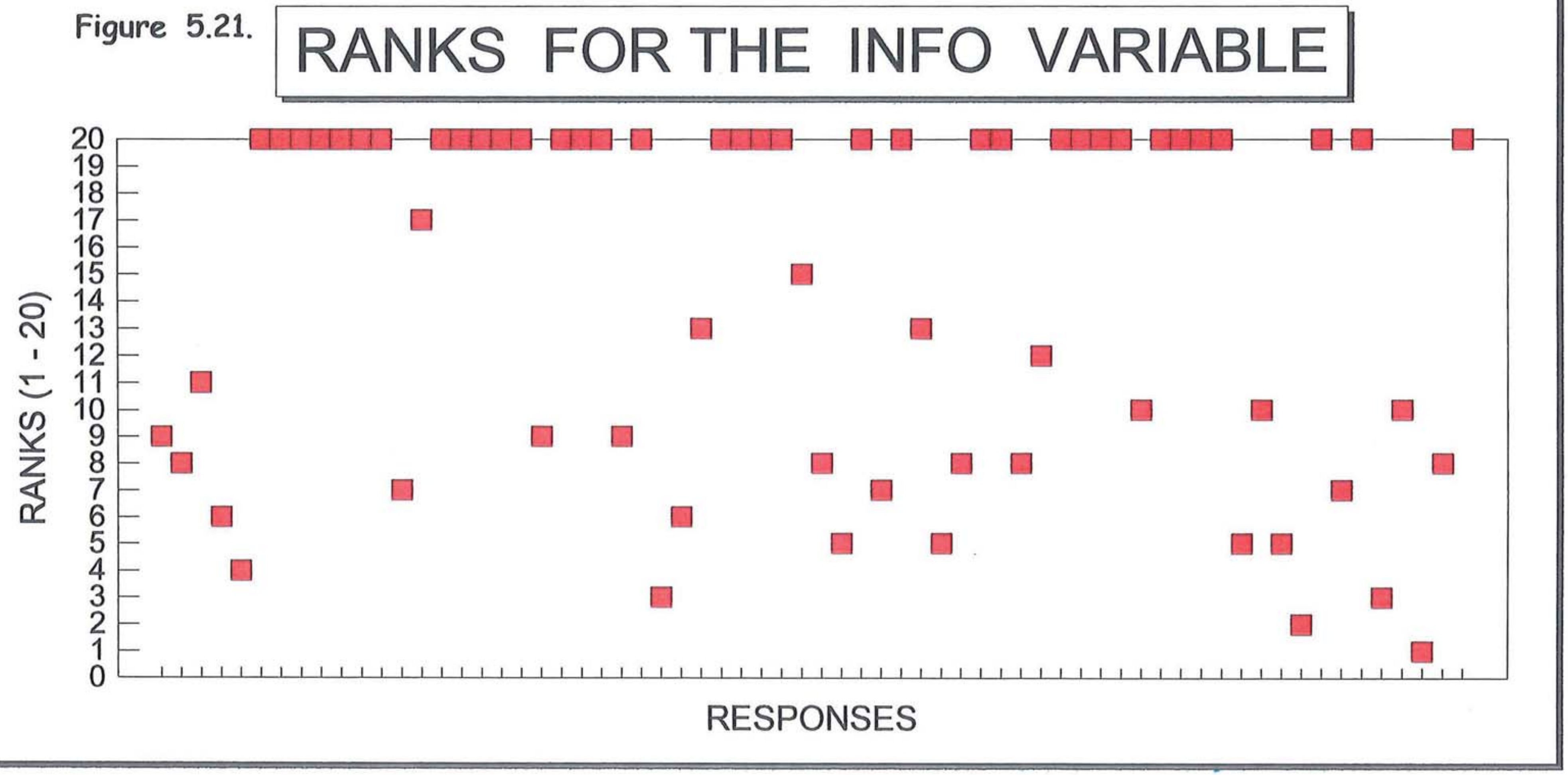


Figure 5.21.



RANKS FOR THE INFO VARIABLE
RANKS (1 - 20)
20
19
18
17
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
RESPONSES

Figure 5.22. RANKS FOR THE LSTD VARIABLE

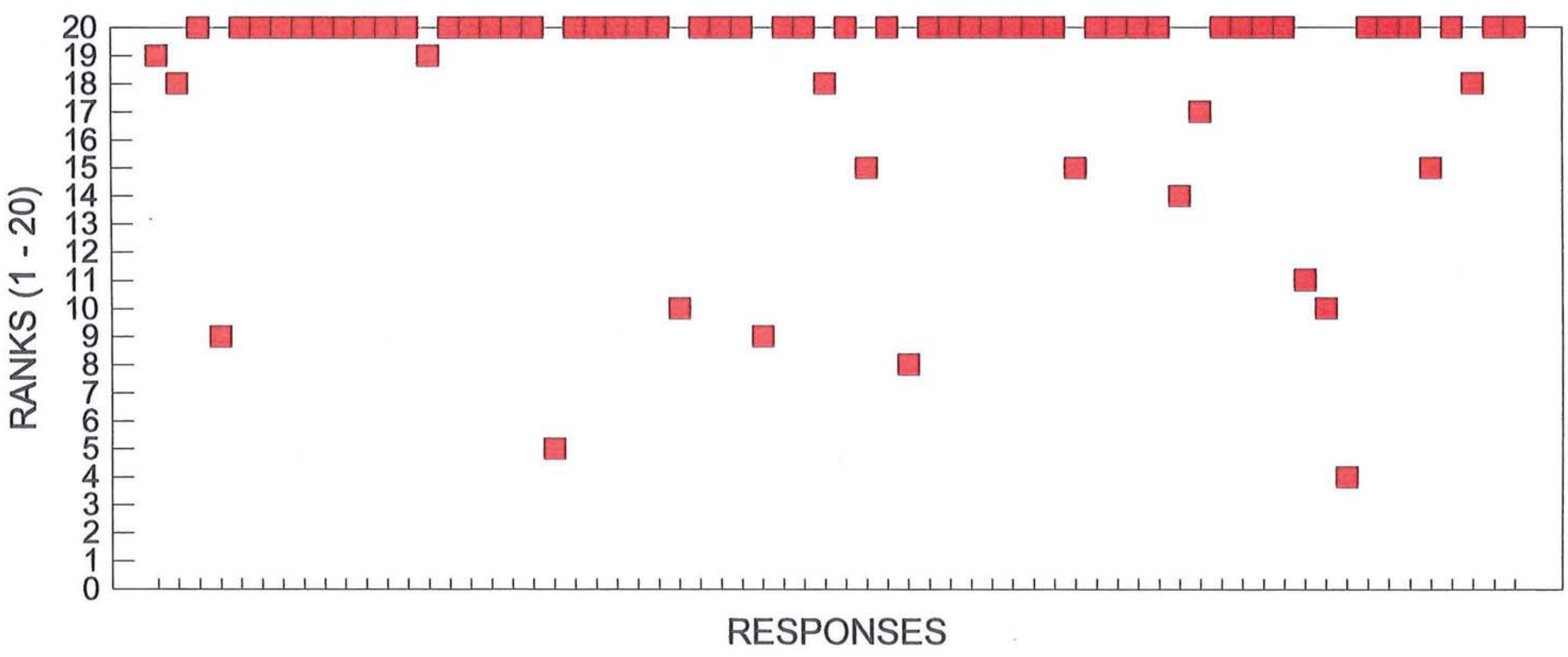
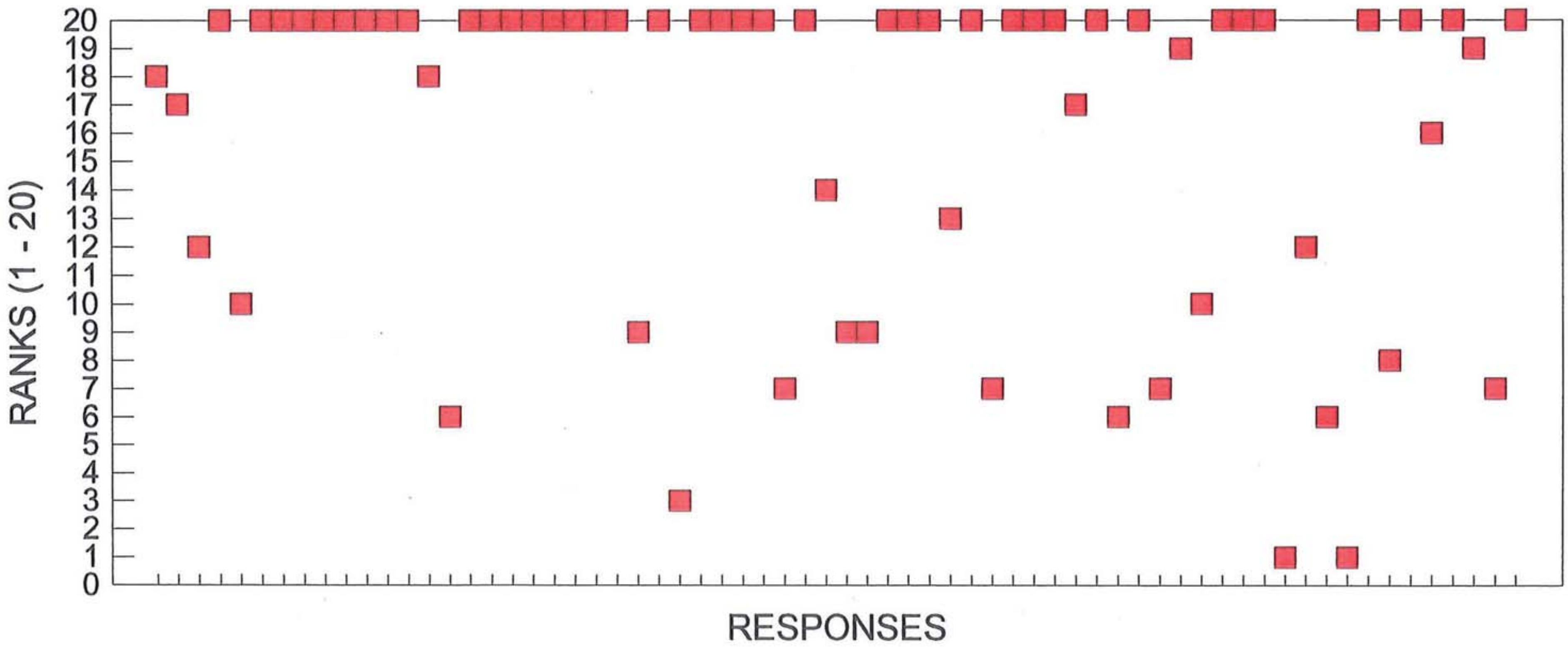


Figure 5.23. RANKS FOR THE INTR VARIABLE



APPENDIX 2

THE RANKS AWARDED BY ORGANISATIONS WITH 1 TO 20 EMPLOYEES.

RANKED FACTORS	RANKS																	
PRIZ	1	2	1	2	5	1	3	2	2	1	3	1	2	3	2	2	1	2
QLTY	3	1	2	1	1	2	1	1	1	2	1	20	1	2	1	1	1	1
DDTE	2	3	3	3	3	3	2	3	3	3	2	2	3	1	3	3	3	3
MTOD	20	20	20	20	20	20	20	20	20	13	4	20	20	20	20	13	11	20
FNCE	20	20	20	20	20	20	20	20	20	13	20	20	20	20	20	15	20	20
CPST	20	20	20	20	20	20	20	20	4	13	6	20	20	20	20	11	5	20
MGTE	20	5	20	20	5	6	20	20	5	7	20	20	20	20	20	12	20	6
TKCE	20	4	4	4	7	5	20	20	6	4	10	20	20	4	20	10	4	5
SMTK	20	20	20	20	20	20	20	20	20	13	20	20	20	20	20	16	20	20
SIZE	20	20	20	20	20	20	20	20	20	13	20	20	20	20	20	19	20	20
GOLK	20	20	20	20	20	20	5	20	20	13	20	20	4	6	4	5	20	9
PIND	20	20	20	20	20	20	20	20	20	5	20	20	20	20	20	20	20	20
REPS	20	20	20	20	8	7	20	20	20	13	7	20	20	20	20	7	7	10
HNST	20	20	20	20	3	20	20	20	20	13	20	20	20	20	20	4	6	20
BKUP	20	6	5	5	3	4	4	4	20	6	8	20	20	20	5	6	8	4
RCMN	20	20	20	20	20	20	20	20	20	13	20	20	5	20	20	9	9	12
LYTY	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	14	20	11
INFO	20	7	20	20	20	20	20	20	20	13	9	20	20	5	20	8	20	8
LSTD	20	8	20	20	20	20	20	20	20	20	5	20	20	20	20	18	10	20
INTR	20	20	20	20	20	20	20	20	20	13	20	20	20	20	20	17	20	7

THE RANKS AWARDED BY ORGANISATIONS WITH BETWEEN 21 AND 50 EMPLOYEES.

RANKED FACTORS	RANKS															
PRIZ	2	1	1	1	1	2	2	2	1	5	1	1	2	1	3	2
QLTY	3	1	20	2	3	1	1	2	2	1	2	1	3	2	1	1
DDTE	1	3	2	3	2	3	3	2	4	4	3	4	4	3	2	3
MTOD	12	20	20	20	8	20	20	20	16	6	20	20	9	20	13	20
FNCE	13	20	20	20	7	20	20	20	13	20	20	20	5	20	8	20
CPST	11	20	20	6	20	20	20	20	12	3	20	20	8	7	5	20
MGTE	4	20	20	20	20	20	20	20	17	20	20	20	7	20	14	20
TKCE	9	5	3	5	9	20	20	20	6	2	20	3	1	9	6	8
SMTK	5	20	20	20	20	20	20	20	19	20	20	20	17	20	16	20
SIZE	18	20	20	20	20	20	20	20	14	20	20	20	16	8	9	20
GOLK	14	20	4	7	5	20	20	20	11	9	20	20	12	20	7	20
PIND	17	20	20	20	10	20	20	20	20	20	20	20	10	20	10	20
REPS	16	7	20	20	20	20	20	20	10	20	7	20	11	5	18	4
HNST	6	6	20	4	4	20	4	20	7	10	5	20	13	11	11	5
BKUP	9	4	20	20	20	4	20	20	8	7	4	20	6	6	4	6
RCMN	15	20	20	20	20	20	20	20	3	20	6	20	19	20	19	20
LYTY	19	20	20	20	20	20	20	20	18	20	20	20	20	20	20	20
INFO	8	20	20	20	20	20	20	20	5	8	8	20	15	4	12	20
LSTD	20	20	20	20	20	20	20	20	15	20	20	20	18	20	15	20
INTR	7	20	20	20	6	20	20	20	9	20	9	20	14	10	17	7

THE RANKS AWARDED BY ORGANISATIONS WITH BETWEEN 51 AND 200 EMPLOYEES.

RANKED FACTORS	RANKS														
PRIZ	2	2	2	3	2	3	1	2	1	2	2	3	3	2	2
QLTY	2	1	1	1	2	1	2	1	2	1	1	1	3	1	1
DDTE	1	3	3	2	2	2	3	3	3	4	3	2	3	20	3
MTOD	20	20	20	7	20	20	12	7	20	6	7	20	20	20	20
FNCE	20	13	20	4	5	20	6	12	20	13	12	20	7	20	20
CPST	20	16	6	5	20	20	11	6	20	3	4	20	3	3	20
MGTE	20	17	20	6	20	20	8	10	20	7	5	7	20	20	4
TKCE	20	4	5	8	20	4	7	5	6	5	6	4	7	20	5
SMTK	20	6	20	20	20	20	13	11	20	15	15	20	20	20	20
SIZE	20	19	20	10	20	20	14	13	20	8	18	20	20	20	20
GOLK	4	7	20	9	5	5	15	15	4	14	16	20	7	20	20
PIND	20	18	20	14	20	20	5	14	20	9	13	20	20	20	20
REPS	20	5	9	16	20	6	20	16	20	16	17	8	9	20	20
HNST	20	8	4	11	20	20	4	8	20	17	9	20	20	4	20
BKUP	20	9	7	12	5	7	16	4	5	10	8	5	3	5	6
RCMN	20	14	20	15	20	20	20	17	20	18	11	20	20	20	20
LYTY	20	15	20	20	20	20	9	20	20	19	20	20	20	20	20
INFO	20	10	8	13	20	20	20	9	20	11	10	6	20	20	20
LSTD	20	11	20	20	20	20	17	19	20	20	14	20	20	20	20
INTR	20	12	20	20	20	20	10	18	20	12	19	20	20	20	7

THE RANKS AWARDED BY ORGANISATIONS WITH BETWEEN 201 AND 1000 EMPLOYEES.

RANKED FACTORS	RANKS											
PRIZ	7	4	2	2	3	2	1	2	2	2	2	5
QLTY	1	2	2	1	3	1	1	1	1	1	2	4
DDTE	2	3	2	3	9	3	9	3	3	3	2	3
MTOD	4	12	5	7	3	6	9	20	20	20	11	7
FNCE	12	6	9	5	9	7	3	20	20	20	6	6
CPST	14	10	5	5	3	4	5	20	20	20	9	8
MGTE	10	8	7	5	9	5	6	20	20	20	8	2
TKCE	8	4	7	7	9	20	4	6	20	20	4	1
SMTK	4	15	16	10	20	20	9	20	20	20	10	20
SIZE	12	14	17	14	20	20	20	12	20	20	15	20
GOLK	16	12	11	15	13	20	9	11	20	20	16	20
PIND	19	17	11	10	13	20	20	10	20	20	14	20
REPS	20	18	11	12	20	20	20	9	6	20	12	20
HNST	10	8	11	12	9	20	20	5	5	20	13	9
BKUP	9	12	9	10	9	20	7	4	4	20	4	20
RCMN	16	15	18	16	20	20	20	20	20	20	17	20
LYTY	16	20	20	20	20	20	20	20	20	20	18	20
INFO	4	6	14	17	9	20	20	7	7	20	6	10
LSTD	16	20	19	19	15	20	20	20	20	20	19	20
INTR	4	1	15	18	3	20	20	8	20	20	20	20

THE RANKS AWARDED BY ORGANISATIONS WITH MORE THAN 1000 EMPLOYEES

RANKED FACTORS	RANKS				
PRIZ	3	3	1	1	3
QLTY	2	1	1	1	1
DDTE	4	2	1	1	4
MTOD	5	20	1	1	7
FNCE	10	6	1	1	8
CPST	6	4	1	1	5
MGTE	8	5	1	1	9
TKCE	7	7	1	1	10
SMTK	9	20	20	1	20
SIZE	11	20	20	1	20
GOLK	13	20	1	2	20
PIND	12	20	1	1	11
REPS	16	20	20	1	20
HNST	17	8	1	20	6
BKUP	14	20	1	1	2
RCMN	15	20	20	1	20
LYTY	20	20	20	20	20
INFO	1	20	20	1	20
LSTD	18	20	20	20	20
INTR	19	20	1	1	20

RANKS AWARDED BY THE ENGINEERING COMPANIES.

Ranked Factors	Awarded Ranks																														AVG	RNK
PRIZ	1	1	2	1	3	2	2	1	1	1	5	3	1	1	1	2	2	1	2	1	2	4	2	1	1	1	2	2	1	5	1.83	1
QLTY	2	2	1	2	2	1	3	1	2	1	1	1	3	3	20	1	1	2	1	1	1	2	1	1	1	1	1	1	1	4	2.17	2
DDTE	3	3	3	3	1	3	1	2	3	1	4	2	2	2	2	3	3	3	3	1	3	3	3	1	2	8	3	3	1	3	2.60	3
MTOD	20	20	20	20	20	20	11	20	20	20	6	13	20	8	20	20	7	12	20	20	20	8	20	2	1	8	20	20	7	7	15.00	12
FNCE	20	20	20	20	20	20	12	20	20	20	20	8	4	7	20	20	12	6	20	2	20	5	13	3	2	2	20	20	3	6	13.50	9
CPST	20	20	20	20	20	20	10	20	6	20	3	5	20	20	20	20	4	11	20	20	6	7	16	2	1	4	20	20	5	8	13.60	10
MGTE	20	6	20	7	20	6	4	20	20	20	20	14	20	20	20	4	5	8	20	20	20	6	17	2	2	5	20	20	4	2	13.07	8
TKCE	4	5	20	4	4	5	9	4	5	20	2	6	20	9	3	5	6	7	20	20	5	4	4	2	2	3	6	20	2	1	7.57	4
SMTK	20	20	20	20	20	20	5	20	20	20	20	16	20	20	20	20	15	13	20	20	20	10	6	7	20	8	20	20	6	20	16.87	16
SIZE	20	20	20	20	20	20	17	20	20	20	20	9	20	20	20	20	18	14	20	20	20	9	19	8	20	20	12	20	11	20	17.90	17
GOLK	20	20	20	20	6	9	13	20	7	20	9	7	20	5	4	20	16	15	4	2	20	8	7	4	3	8	11	20	12	20	12.33	6
PIND	20	20	20	5	20	20	16	20	20	20	20	10	20	10	20	20	13	5	20	20	20	11	18	4	3	20	10	20	10	20	15.83	15
REPS	20	7	20	20	20	10	15	6	20	20	20	18	6	20	20	20	17	20	20	20	9	12	5	4	20	20	9	20	8	20	15.53	14
HNST	20	20	20	20	20	20	6	5	4	20	10	11	20	4	20	20	9	4	20	20	4	6	8	4	2	20	5	20	9	9	12.67	7
BKUP	5	4	4	6	20	4	9	3	20	20	7	4	5	20	20	6	8	16	5	2	7	8	9	3	2	6	4	20	2	20	8.97	5
RCMN	20	20	20	20	20	12	14	20	20	20	20	19	20	20	20	20	11	20	20	20	20	10	14	9	20	20	20	20	13	20	18.07	18
LYTY	20	20	20	20	20	11	18	20	20	20	20	20	20	20	20	20	20	9	20	20	20	20	15	11	20	20	20	20	14	20	18.60	20
INFO	20	20	20	20	5	8	8	20	20	20	8	12	20	20	20	20	10	20	20	20	8	5	10	5	2	20	7	20	3	10	14.03	11
LSTD	20	20	20	20	20	20	20	20	20	20	20	15	20	20	20	20	14	17	20	20	20	20	11	10	4	20	20	20	15	20	18.20	19
INTR	20	20	20	20	20	7	7	20	20	20	20	17	20	6	20	7	19	10	20	20	20	1	12	6	1	20	8	20	16	20	15.23	13

RANKS AWARDED BY THE PROCESS INDUSTRIES .

Ranked Factors	Awarded Ranks															AVG	RNK
PRIZ	3	3	1	2	4	3	3	1	1	2	1	2	1	1	2	2.00	2
QLTY	1	1	1	1	1	1	1	2	1	1	1	3	2	2	1	1.33	1
DDTE	2	4	1	3	2	2	2	3	2	3	1	4	3	4	3	2.60	3
MTOD	20	7	1	6	3	20	7	20	10	20	20	9	20	16	20	13.27	11
FNCE	6	8	1	7	8	20	4	20	20	20	20	5	20	13	20	12.80	9
CPST	4	5	1	4	9	20	5	20	4	20	20	8	20	12	20	11.47	6
MGTE	5	9	1	5	7	7	6	20	20	20	20	7	20	17	20	12.27	7
TKCE	7	10	1	20	5	4	8	6	3	8	20	1	20	6	4	8.20	4
SMTK	20	20	1	20	3	20	20	20	20	20	20	17	20	19	20	17.33	18
SIZE	20	20	1	20	8	20	10	20	20	20	20	16	20	14	20	16.60	17
GOLK	20	20	1	20	10	20	9	4	20	20	1	12	20	11	20	13.87	12
PIND	20	11	1	20	11	20	14	20	20	20	20	10	20	20	20	16.47	16
REPS	20	20	1	20	12	8	16	20	6	4	20	11	7	10	20	13.00	10
HNST	8	6	20	20	7	20	11	20	5	5	20	13	5	7	20	12.47	8
BKUP	20	2	1	20	6	5	12	5	7	6	20	6	4	8	5	8.47	5
RCMN	20	20	1	20	10	20	15	20	8	20	20	19	6	3	20	14.80	14
LYTY	20	20	20	20	10	20	20	20	20	20	20	20	20	18	20	19.20	20
INFO	20	20	1	20	3	6	13	20	20	20	20	15	8	5	20	14.07	13
LSTD	20	20	20	20	10	20	20	20	9	20	20	18	20	15	20	18.13	19
INTR	20	20	1	20	3	20	20	20	20	7	20	14	9	9	20	14.87	15

RANKS AWARDED BY THE PRINTING & PACKAGING INDUSTRIES .

Ranked Factors	Awarded Ranks							' AVG	'RNK
PRIZ	2	2	2	5	1	2	3	2.43	2
QLTY	1	1	1	1	2	1	1	1.14	1
DDTE	3	3	4	2	3	3	2	2.86	3
MTOD	7	13	6	20	20	20	20	15.14	11
FNCE	12	15	13	20	20	20	20	17.14	16.5
CPST	6	11	3	20	7	20	20	12.43	8
MGTE	10	12	7	20	20	20	20	15.57	13.5
TKCE	5	10	5	20	9	20	20	12.71	9
SMTK	11	16	15	20	20	20	20	17.43	18
SIZE	13	19	8	20	8	20	20	15.43	12
GOLK	15	5	14	3	20	4	5	9.43	4
PIND	14	20	9	20	20	20	20	17.57	19
REPS	16	7	16	8	5	20	20	13.14	10
HNST	8	4	17	4	11	20	20	12.00	7
BKUP	4	6	10	20	6	20	4	10.00	5
RCMN	17	9	18	20	20	5	20	15.57	13.5
LYTY	20	14	19	7	20	20	20	17.14	16.5
INFO	9	8	11	6	4	20	20	11.14	6
LSTD	19	18	20	9	20	20	20	18.00	20
INTR	18	17	12	20	10	20	20	16.71	15

RANKS AWARDED BY THE TEXTILE INDUSTRIES .

Ranked Factors	Awarded Ranks					' AVG	'RNK
PRIZ	2	1	2	1	2	1.60	1
QLTY	1	1	1	20	1	4.80	2
DDTE	20	1	3	2	3	5.80	3
MTOD	20	20	20	20	20	20.00	20
FNCE	20	2	20	20	20	16.40	8.5
CPST	3	1	20	20	4	9.60	4
MGTE	20	20	20	20	5	17.00	11
TKCE	20	2	20	20	6	13.60	6.5
SMTK	20	20	20	20	20	20.00	20
SIZE	20	20	20	20	20	20.00	20
GOLK	20	2	20	20	20	16.40	8.5
PIND	20	20	20	20	20	20.00	20
REPS	20	3	20	20	20	16.60	10
HNST	4	20	4	20	20	13.60	6.5
BKUP	5	1	20	20	20	13.20	5
RCMN	20	20	20	20	20	20.00	20
LYTY	20	20	20	20	20	20.00	20
INFO	20	20	20	20	20	20.00	20
LSTD	20	20	20	20	20	20.00	20
INTR	20	20	20	20	20	20.00	20

RANKS AWARDED BY THE SERVICES INDUSTRIES .

Ranked Factors	Awarded Ranks									' AVG	'RNK
PRIZ	2	2	1	3	3	2	1	3	3	2.22	2
QLTY	1	1	3	1	2	1	1	1	1	1.33	1
DDTE	3	3	2	2	1	3	3	2	2	2.33	3
MTOD	20	7	20	20	20	20	20	4	20	16.78	10
FNCE	20	4	20	20	20	20	20	20	20	18.22	14
CPST	20	4	20	20	20	20	20	6	20	16.67	9
MGTE	20	4	20	20	20	20	20	20	3	16.33	8
TKCE	20	7	20	4	5	20	2	10	4	10.22	5
SMTK	20	8	20	20	20	20	20	20	20	18.67	16
SIZE	20	14	20	20	20	20	20	20	20	19.33	18
GOLK	20	15	20	5	20	20	20	20	20	17.78	12
PIND	20	9	20	20	20	20	20	20	20	18.78	17
REPS	6	12	20	6	20	20	20	7	8	13.22	6
HNST	5	12	20	20	7	20	20	20	2	14.00	7
BKUP	4	9	20	7	4	4	20	8	2	8.67	4
RCMN	20	16	20	20	20	20	20	20	20	19.56	19
LYTY	20	20	20	20	20	20	20	20	20	20.00	20
INFO	7	17	20	20	20	20	20	9	20	17.00	11
LSTD	20	19	20	20	20	20	20	5	20	18.22	14
INTR	20	18	20	20	6	20	20	20	20	18.22	14

	THE RANKS AS AWARDED TO THE FNCE. FACTOR.									
1 - 20 EMPL.		21 - 50 EMPL.		51 - 200 EMPL.		201 - 1000 EMPL.		> 1000 EMPL.		
(R)	(R/R)	(R)	(R/R)	(R)	(R/R)	(R)	(R/R)	(R)	R/R)	
20	48	13	26	20	48	12	22	10	20	
20	48	20	48	13	26	6	10	6	10	
20	48	20	48	20	48	9	18.5	1	1.5	
20	48	20	48	4	4	5	5	1	1.5	
20	48	7	14	5	6	9	18.5	8	16.5	
20	48	20	48	20	48	7	14			
20	48	20	48	6	10	3	3			
20	48	20	48	12	22	20	48			
20	48	13	26	20	48	20	48			
13	26	20	48	13	26	20	48			
20	48	20	48	12	22	6	10			
20	48	20	48	20	48	6	10			
20	48	5	6	7	14					
20	48	20	48	20	48			n = 5		
20	48	8	16.5	20	48					
15	29	20	48							
20	48					n = 12				
20	48			n = 15						
		n = 16								
n = 18										
SUM =	823		616.5		466		255		49.5	
SUM(sq) =	677329		380072.3		217156		65025		2450.25	
SUMsq/n=	37629.39		23754.52		14477.1		5418.75		490.05	
							Ranks	Freq.	R. of Rank	
tot. N = 66		K =	81769.77				1	2	1.5	
				981237.3			3	1	3	
				4422			4	1	4	
				221.899			5	3	6	
		H =	20.89897		201		6	5	10	
							7	3	14	
							8	2	16.5	
							9	2	18.5	
							10	1	20	
							12	3	22	
							13	5	26	
							15	1	29	
							20	37	48	
correction for ties										
	T =	6	24	120	24	6	6	24	120	50616
		=	50946							
	N = 66									
		287430								
		coeff. =	0.822753							
				corrected H						
				=	25.4013					

	THE RANKS AS AWARDED TO THE CPST. FACTOR.									
1 - 20 EMPL.		21 - 50 EMPL.		51 - 200 EMPL.		201 - 1000 EMPL.		> 1000 EMPL.		
(R)	(R/R)	(R)	(R/R)	(R)	(R/R)	(R)	(R/R)	(R)	R/R)	
20	51	11	30	20	51	14	34	6	21	
20	51	20	51	16	35	10	28	4	9.5	
20	51	20	51	6	21	5	15	1	1.5	
20	51	6	21	5	15	5	15	1	1.5	
20	51	20	51	20	51	3	5	5	15	
20	51	20	51	20	51	4	9.5			
20	51	20	51	11	30	5	15			
20	51	20	51	6	21	20	51			
4	9.5	12	32	20	51	20	51			
13	33	3	5	3	5	20	51			
6	21	20	51	4	9.5	9	28			
20	51	20	51	20	51	8	25.5			
20	51	8	25.5	3	5					
20	51	7	24	3	5			n = 5		
20	51	5	15	20	51					
11	30	20	51							
5	15					n = 12				
20	51			n = 15						
		n = 16								
n = 18										
SUM =	771.5		611.5		452.5		328		48.5	
SUM(sq) =	595212.3		373932.3		204756		107584		2352.25	
SUMsq/n=	33067.35		23370.77		13650.4		8965.33		470.45	
							Ranks	Freq.	R. of Rank	
tot. N = 66		K =	79524.31				1	2	1.5	
				954291.8			3	5	5	
				4422			4	4	9.5	
				215.8055			5	7	15	
		H =	14.80546		201		6	5	21	
							7	1	24	
							8	2	25.5	
							9	1	27	
							10	1	28	
							11	3	30	
							12	1	32	
							13	1	33	
							14	1	34	
							16	1	35	
correction for ties							20	31	51	
	T =	6	120	60	336	120	6	24	29760	
		=	30432							
	N = 66									
		287430								
		coeff. =	0.894124							
				corrected H						
				=	16.5586					

	THE RANKS AS AWARDED TO THE REPS. FACTOR.											
1 - 20 EMPL.		21 - 50 EMPL.		51 - 200 EMPL.		201 - 1000 EMPL		> 1000 EMPL.				
(R)	(R/R)	(R)	(R/R)	(R)	(R/R)	(R)	(R/R)	(R)	R/R)			
20	49.5	16	27	20	49.5	20	49.5	16	26			
20	49.5	7	9.5	5	3.5	18	31.5	20	49.5			
20	49.5	20	49.5	9	16	11	20.5	20	49.5			
20	49.5	20	49.5	16	27	12	22.5	1	1			
8	13.5	20	49.5	20	49.5	20	49.5	20	49.5			
7	9.5	20	49.5	6	5.5	20	49.5					
20	49.5	20	49.5	20	49.5	20	49.5					
20	49.5	20	49.5	16	27	9	16					
20	49.5	10	18.5	20	49.5	6	5.5					
13	24	20	49.5	16	27	20	49.5					
7	9.5	7	9.5	17	30	12	22.5					
20	49.5	20	49.5	8	13.5	20	49.5					
20	49.5	11	20.5	9	16							
20	49.5	5	3.5	20	49.5			n = 5				
20	49.5	18	31.5	20	49.5							
7	9.5	4	2									
7	9.5					n = 12						
10	18.5			n = 15								
		n = 16										
n = 18												
SUM =	638.5		518		462.5		415.5		175.5			
SUM(sq) =	407682.3		268324		213906		172640		30800.3			
SUMsq/n=	22649.01		16770.25		14260.4		14386.7		6160.05			
							Ranks	Freq.	R. of Rank			
tot. N = 66		K =	74226.42				1	1	1			
				890717			4	1	2			
				4422			5	2	3.5			
				201.4285			6	2	5.5			
		H =	0.428543		201		7	6	9.5			
							8	2	13.5			
							9	3	16			
							10	2	18.5			
							11	2	20.5			
							12	2	22.5			
							13	1	24			
							16	5	27			
							17	1	30			
							18	2	31.5			
correction	for ties						20	34	49.5			
	T =	6	6	210	6	24	6	6	6	120	6	39270
		=	39666									
	N = 66											
		287430										
		coeff. =	0.861998									
				corrected H								
				=	0.49715							

APPENDIX 3

	THE RANKS AS AWARDED TO THE PRIZ. FACTOR.								
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES	
1	13.5	3	56	2	38.5	2	38.5	2	38.5
1	13.5	3	56	2	38.5	1	13.5	2	38.5
2	38.5	1	13.5	2	38.5	2	38.5	1	13.5
1	13.5	2	38.5	5	65	1	13.5	3	56
3	56	4	62.5	1	13.5	2	38.5	3	56
2	38.5	3	56	2	38.5			2	38.5
2	38.5	3	56	3	56			1	13.5
1	13.5	1	13.5			n = 5		3	56
1	13.5	1	13.5				142.5	3	56
1	13.5	2	38.5	n = 7			20306.3		
5	65	1	13.5		288.5		4061.25		
3	56	2	38.5		83232.3			n = 9	
1	13.5	1	13.5		11890.3				366.5
1	13.5	1	13.5						134322
1	13.5	2	38.5						14924.7
2	38.5								
2	38.5								
1	13.5	n = 15							
2	38.5		521.5		Ranks	Freq.	R. of Rank		
1	13.5		271962.25		1	26	13.5		
2	38.5		18130.82		2	24	38.5		
4	62.5				3	11	56		
2	38.5				4	2	62.5		
1	13.5				5	3	65		
1	13.5								
1	13.5								
2	38.5								
2	38.5								
1	13.5								
5	65								
tot N = 66									
n = 30									
SUM =	892			906350.6					
SUM sq. =	795664			4422					
SUMsq/n=	26522			204.964	201				
		K =	75529.22						
		H =	3.963951						
correction for ties									
	T =	17550	13800	1320	6	24			
		=	32700						
	N = 66								
		287430							
			0.886233						
				corrected H					
				=	4.47281				

	THE RANKS AS AWARDED TO THE QLTY. FACTOR.								
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES	
2	52	1	23	1	23	1	23	1	23
2	52	1	23	1	23	1	23	1	23
1	23	1	23	1	23	1	23	3	61
2	52	1	23	1	23	20	65.5	1	23
2	52	1	23	2	52	2	52	2	52
1	23	1	23	1	23			1	23
3	61	1	23	1	23			1	23
1	23	2	52			n = 5		1	23
2	52	1	23				186.5	1	23
1	23	1	23	n = 7			34782.3		
1	23	1	23		190		6956.45		
1	23	3	61		36100			n = 9	
3	61	2	52		5157.14				274
3	61	2	52						75076
20	65.5	1	23						8341.78
1	23								
1	23								
2	52	n = 15							
1	23		470		Ranks	Freq.	R. of Rank		
1	23		220900.00		1	45	23		
1	23		14726.67		2	13	52		
2	52				3	5	61		
1	23				4	1	64		
1	23				20	2	65.5		
1	23								
1	23								
1	23								
1	23								
1	23								
4	64								
tot N = 66									
n = 30									
SUM =	1090.5			897860.5					
SUM sq. =	1189190			4422					
SUMsq/n=	39639.68			203.044	201				
		K =	74821.71						
		H =	2.043995						
correction	for ties								
	T =	91080	2184	120	6	0			
		=	93390						
	N = 66								
		287430							
		coeff. =	0.675086						
				corrected H					
				=	3.02776				

	' THE RANKS AS AWARDED TO THE DDTE. FACTOR.								
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES	
3	44	2	19.5	3	44	20	66	3	44
3	44	4	62	3	44	1	5.5	3	44
3	44	1	5.5	4	62	3	44	2	19.5
3	44	3	44	2	19.5	2	19.5	2	19.5
1	5.5	2	19.5	3	44	3	44	1	5.5
3	44	2	19.5	3	44			3	44
1	5.5	2	19.5	2	19.5			3	44
2	19.5	3	44			n = 5		2	19.5
3	44	2	19.5				179	2	19.5
1	5.5	3	44	n = 7			32041		
4	62	1	5.5		277		6408.2		
2	19.5	4	62		76729			n = 9	
2	19.5	3	44		10961.3				259.5
2	19.5	4	62						67340.3
2	19.5	3	44						7482.25
3	44								
3	44								
3	44	n = 15							
3	44		514.5		Ranks	Freq.	R. of Rank		
1	5.5		264710.25		1	10	5.5		
3	44		17647.35		2	18	19.5		
3	44				3	31	44		
3	44				4	5	62		
1	5.5				8	1	65		
2	19.5				20	1	66		
8	65								
3	44								
3	44								
1	5.5								
3	44								
tot N = 66									
n =.30									
SUM =	981			894933.4					
SUM sq. =	962361			4422					
SUMsq/n=	32078.7			202.3821	201				
		K =	74577.79						
		H =	1.382051						
correction	for ties								
	T =	990	5814	29760	120	0			
		=	36684						
	N = 66								
		287430							
		coeff. =	0.872372						
				corrected H					
				=	1.58424				

	THE RANKS AS AWARDED TO THE MTOD. FACTOR.								
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES	
20	46	20	46	7	12	20	46	20	46
20	46	7	12	13	23.5	20	46	7	12
20	46	1	1.5	6	7	20	46	20	46
20	46	6	7	20	46	20	46	20	46
20	46	3	4	20	46	20	46	20	46
20	46	20	46	20	46			20	46
11	21	7	12	20	46			20	46
20	46	20	46			n = 5		4	5
20	46	10	20				230	20	46
20	46	20	46	n = 7			52900		
6	7	20	46		226.5		10580		
13	23.5	9	19		51302.3			n = 9	
20	46	20	46		7328.89				339
8	17	16	25						114921
20	46	20	46						12769
20	46								
7	12								
12	22	n = 15							
20	46		422.5		Ranks	Freq.	R. of Rank		
20	46		178506.25		1	2	1.5		
20	46		11900.42		2	1	3		
8	17				3	1	4		
20	46				4	1	5		
2	3				6	3	7		
1	1.5				7	7	12		
8	17				8	3	17		
20	46				9	1	19		
20	46				10	1	20		
7	12				11	1	21		
7	12				12	1	22		
					13	2	23.5		
tot N = 66					16	1	25		
n = 30					20	41	46		
SUM =	993			905359.3					
SUM sq. =	986049			4422					
SUMsq/n=	32868.3			204.7398	201				
		K =	75446.61						
		H =	3.739782						
correction	for ties								
	T =	6	24	336	24	6	68880		
		=	69276						
	N = 66								
		287430							
		coeff. =	0.758981						
				corrected H					
				=	4.92737				

	THE RANKS AS AWARDED TO THE FNCE. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	47	6	14	12	22	20	47	20	47		
20	47	8	19	15	27	2	3.5	4	9		
20	47	1	1	13	25	20	47	20	47		
20	47	7	16.5	20	47	20	47	20	47		
20	47	8	19	20	47	20	47	20	47		
20	47	20	47	20	47			20	47		
12	22	4	9	20	47			20	47		
20	47	20	47			n = 5		20	47		
20	47	20	47				191.5	20	47		
20	47	20	47	n = 7			36672.3				
20	47	20	47		262		7334.45				
8	19	5	11.5		68644			n = 9			
4	9	20	47		9806.29				385		
7	16.5	13	25						148225		
20	47	20	47						16469.4		
20	47										
12	22										
6	14	n = 15									
20	47		444		Ranks	Freq.	R. of Rank				
2	3.5		197136.00		1	1	1				
20	47		13142.4		2	4	3.5				
5	11.5				3	2	6.5				
13	25				4	3	9				
3	6.5				5	2	11.5				
2	3.5				6	3	14				
2	3.5				7	2	16.5				
20	47				8	3	19				
20	47				12	3	22				
3	6.5				13	3	25				
6	14				15	1	27				
					20	39	47				
tot N = 66											
n = 30											
SUM =	928.5			905875.9							
SUM sq. =	862112.3			4422							
SUMsq/n=	28737.08			204.8566	201						
		K =	75489.66								
		H =	3.856595								
correction for ties											
	T =	60	6	24	6	24	6	24	24	24	59280
		=	59478								
	N = 66										
		287430									
		coeff. =	0.79307								
				corrected H							
				=	4.86287						

	THE RANKS AS AWARDED TO THE CPST. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	49.5	4	11	6	20.5	3	6	20	49.5		
20	49.5	5	16.5	11	39.5	1	2	4	11		
20	49.5	1	2	3	6	20	49.5	20	49.5		
20	49.5	4	11	20	49.5	20	49.5	20	49.5		
20	49.5	9	27	7	23.5	4	11	20	49.5		
20	49.5	20	49.5	20	49.5			20	49.5		
10	28	5	16.5	20	49.5			20	49.5		
20	49.5	20	49.5			n = 5		6	20.5		
6	20.5	4	11				118	20	49.5		
20	49.5	20	49.5	n = 7			13924				
3	6	20	49.5		238		2784.8				
5	16.5	8	25.5		56644			n = 9			
20	49.5	20	49.5		8092				378		
20	49.5	12	31						142884		
20	49.5	20	49.5						15876		
20	49.5										
4	11										
11	39.5	n = 15									
20	49.5		448.5		Ranks	Freq.	R. of Rank				
20	49.5		201152.25		1	3	2				
6	20.5		13410.15		2	1	4				
7	23.5				3	3	6				
16	32				4	7	11				
2	4				5	4	16.5				
1	2				6	4	20.5				
4	11				7	2	23.5				
20	49.5				8	2	25.5				
20	49.5				9	1	27				
5	16.5				10	1	28				
8	25.5				11	2	29.5				
					12	1	31				
tot N = 66					16	1	32				
n = 30					20	34	49.5				
SUM =	1048.5			921696.3							
SUM sq. =	1099352			4422							
SUMsq/n=	36645.08			208.4343	201						
		K =	76808.03								
		H =	7.434261								
correction for ties											
	T =	24	24	336	60	60	6	6	6	39270	
		=	39792								
	N = 66										
		287430									
		coeff. =	0.861559								
				corrected H							
				=	8.62884						

	THE RANKS AS AWARDED TO THE MGTE. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	48.5	5	12	10	26	20	48.5	20	48.5		
6	16.5	9	25	12	27	20	48.5	4	7.5		
20	48.5	1	1	7	21	20	48.5	20	48.5		
7	21	5	12	20	48.5	20	48.5	20	48.5		
20	48.5	7	21	20	48.5	5	12	20	48.5		
6	16.5	7	21	20	48.5			20	48.5		
4	7.5	6	16.5	20	48.5			20	48.5		
20	48.5	20	48.5			n = 5		20	48.5		
20	48.5	20	48.5				206	3	5		
20	48.5	20	48.4	n = 7			42436				
20	48.5	20	48.5		268		8487.2				
14	28	7	21		71824			n = 9			
20	48.5	20	48.5		10260.6				352		
20	48.5	17	29.5						123904		
20	48.5	20	48.5						13767.1		
4	7.5										
5	12										
8	24	n = 15									
20	48.5		449.9		Ranks	Freq.	R. of Rank				
20	48.5		202410.01		1	1	1				
20	48.5		13494		2	3	3				
6	16.5				3	1	5				
17	29.5				4	4	7.5				
2	3				5	5	12				
2	3				6	4	16.5				
5	12				7	5	21				
20	48.5				8	1	24				
20	48.5				9	1	25				
4	7.5				10	1	26				
2	3				12	1	27				
					14	1	28				
tot N = 66					17	2	29.5				
n = 30					20	36	48.5				
SUM =	935			901796.6							
SUM sq. =	874225			4422							
SUMsq/n=	29140.83			203.9341	201						
		K =	75149.72								
		H =	2.934102								
correction for ties											
	T =	24	60	120	60	120	6	46620			
		=	47010								
	N = 66										
		287430									
		coeff. =	0.836447								
				corrected H							
				=	3.50782						

	THE RANKS AS AWARDED TO THE TKCE. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
4	17.5	7	39	5	27	20	57.5	20	57.5		
5	27	10	47	10	47	2	6.5	7	39		
20	57.5	1	2	5	27	20	57.5	20	57.5		
4	17.5	20	57.5	20	57.5	20	57.5	4	17.5		
4	17.5	5	27	9	44	6	34.5	5	27		
5	27	4	17.5	20	57.5			20	57.5		
9	44	8	41.5	20	57.5			2	6.5		
4	17.5	6	34.5			n = 5		10	37		
5	27	3	11				213.5	4	17.5		
20	57.5	8	41.5	n = 7			45582.3				
2	6.5	20	57.5		317.5		9116.45				
6	34.5	1	2		100806			n = 9			
20	57.5	20	57.5		14400.9				317		
9	44	6	34.5						100489		
3	11	4	17.5						11165.4		
5	27										
6	34.4										
7	39	n = 15									
20	57.5		487.5		Ranks	Freq.	R. of Rank				
20	57.5		237656.25		1	3	2				
5	27		15843.75		2	6	6.5				
4	17.5				3	3	11				
4	17.5				4	10	17.5				
2	6.5				5	9	27				
2	6.5				6	6	34.5				
3	11				7	3	39				
6	34.5				8	2	41.5				
20	57.5				9	3	44				
2	6.5				10	3	47				
1	2				20	18	57.5				
tot N = 66											
n = 30											
SUM =	865.4			905885.3							
SUM sq. =	748917.2			4422							
SUMsq/n=	24963.91			204.8587	201						
		K =	75490.44								
		H =	3.858732								
correction for ties											
	T =	24	210	24	990	720	210	24	6	48	5814
		=	8070								
	N = 66										
		287430									
		coeff. =	0.971924								
				corrected H							
				=	3.9702						

	THE RANKS AS AWARDED TO THE SMTK. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	42	20	42	11	10	20	42	20	42		
20	42	20	42	16	14.5	20	42	8	7.5		
20	42	1	1	15	12.5	20	42	20	42		
20	42	20	42	20	42	20	42	20	42		
20	42	3	2	20	42	20	42	20	42		
20	42	20	42	20	42			20	42		
5	3	20	42	20	42			20	42		
20	42	20	42			n = 5		20	42		
20	42	20	42				210	20	42		
20	42	20	42	n = 7			44100				
20	42	20	42		205		8820				
16	14.5	17	16		42025			n = 9			
20	42	20	42		6003.57				343.5		
20	42	19	17						117992		
20	42	20	42						13110.3		
20	42										
15	12.5										
13	11	n = 15									
20	42		498		Ranks	Freq.	R. of Rank				
20	42		248004.00		1	1	1				
20	42		16533.6		3	1	2				
10	9				5	1	3				
6	4.5				6	2	4.5				
7	6				7	1	6				
20	42				8	2	7.5				
8	7.5				10	1	9				
20	42				11	1	10				
20	42				13	1	11				
6	4.5				15	2	12.5				
20	42				16	2	14.5				
					17	1	16				
tot N = 66					19	1	17				
n = 30					20	49	42				
SUM =	954.5			898037.2							
SUM sq. =	911070.3			4422							
SUMsq/n=	30369.01			203.0839	201						
		K =	74836.43								
		H =	2.083934								
correction for ties											
	T =	6	6	6	6	117600					
		=	117624								
	N = 66										
		287430									
		coeff. =	0.590773								
				corrected H							
				=	3.52747						

	THE RANKS AS AWARDED TO THE SIZE FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	43	20	43	13	11	20	43	20	43		
20	43	20	43	19	18.5	20	43	14	13		
20	43	1	1	8	3.5	20	43	20	43		
20	43	20	43	20	43	20	43	20	43		
20	43	8	3.5	8	3.5	20	43	20	43		
20	43	20	43	20	43			20	43		
17	16	10	8	20	43			20	43		
20	43	20	43			n = 5		20	43		
20	43	20	43				215	20	43		
20	43	20	43	n = 7			46225				
20	43	20	43		165.5		9245				
9	5.5	16	15		27390.3			n = 9			
20	43	20	43		3912.89				357		
20	43	14	13						127449		
20	43	20	43						14161		
20	43										
18	17										
14	13	n = 15									
20	43		470.5		Ranks	Freq.	R. of Rank				
20	43		221370.25		1	1	1				
20	43		14758.02		8	4	3.5				
9	5.5				9	2	5.5				
19	18.5				10	1	8				
8	3.5				11	1	9				
20	43				12	1	10				
20	43				13	1	11				
12	10				14	3	13				
20	43				16	1	15				
11	9				17	1	16				
20	43				18	1	17				
					19	2	18.5				
tot N = 66					20	47	43				
n = 30											
SUM =	1001			905723.3							
SUM sq. =	1002001			4422							
SUMsq/n=	33400.03			204.8221	201						
		K =	75476.94								
		H =	3.822097								
correction	for ties										
	T =	60	6	24	6	103776					
		=	103872								
	N = 66										
		287430									
		coeff. =	0.638618								
				corrected H							
				=	5.98495						

	THE RANKS AS AWARDED TO THE GOLK FACTOR.												
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES					
20	51	20	51	15	33	20	51	20	51				
20	51	20	51	5	13.5	2	3.5	15	33				
20	51	1	1.5	14	31	20	51	20	51				
20	51	20	51	3	5.5	20	51	5	13.5				
6	16	10	25	20	51	20	51	20	51				
9	23	20	51	4	9			20	51				
13	30	9	23	5	13.5			20	51				
20	51	4	9			n = 5		20	51				
7	18	20	51				207.5	20	51				
20	51	20	51	n = 7			43056.3						
9	23	1	1.5		156.5		8611.25						
7	18	12	28.5		24492.3			n = 9					
20	51	20	51		3498.89				403.5				
5	13.5	11	26.5						162812				
4	9	20	51						18090.3				
20	51												
16	35						Ranks	Freq.	R. of Rank				
15	33	n = 15					1	2	1.5				
4	9		523				2	2	3.5				
2	3.5		273529.00				3	2	5.5				
20	51		18235.27				4	5	9				
8	20.5						5	4	13.5				
7	18						6	1	16				
4	9						7	3	18				
3	5.5						8	2	20.5				
8	20.5						9	3	23				
11	26.5						10	1	25				
20	51						11	2	26.5				
12	28.5						12	2	28.5				
20	51						13	1	30				
							14	1	31				
tot N = 66							15	3	33				
n = 30							16	1	35				
SUM =	920.5			920156			20	31	51				
SUM sq. =	847320.3			4422									
SUMsq/n=	28244.01			208.0859	201								
		K =	76679.67										
		H =	7.085937										
correction for ties													
	T =	6	6	6	120	60	24	6	24	6	6	24	29760
		=	30048										
	N = 66												
		287430											
		coeff. =	0.89546										
				corrected H									
				=	7.91318								

	THE RANKS AS AWARDED TO THE PIND FACTOR.								
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES	
20	43.5	20	43.5	14	17.5	20	43.5	20	43.5
20	43.5	11	14	20	43.5	20	43.5	9	6.5
20	43.5	1	1	9	6.5	20	43.5	20	43.5
5	4.5	20	43.5	20	43.5	20	43.5	20	43.5
20	43.5	11	14	20	43.5	20	43.5	20	43.5
20	43.5	20	43.5	20	43.5			20	43.5
16	19	14	17.5	20	43.5			20	43.5
20	43.5	20	43.5			n = 5		20	43.5
20	43.5	20	43.5				217.5	20	43.5
20	43.5	20	43.5	n = 7			47306.3		
20	43.5	20	43.5		241.5		9461.25		
10	10	10	10		58322.3			n = 9	
20	43.5	20	43.5		8331.75				354.5
10	10	20	43.5						125670
20	43.5	20	43.5						13963.4
20	43.5								
13	16						Ranks	Freq.	R. of Rank
5	4.5	n = 15					1	1	1
20	43.5		491.5				3	1	2
20	43.5		241572.25				4	1	3
20	43.5		16104.82				5	2	4.5
11	14						9	2	6.5
18	20						10	5	10
4	3						11	3	14
3	2						13	1	16
20	43.5						14	2	17.5
10	10						16	1	19
20	43.5						18	1	20
10	10						20	46	43.5
20	43.5								
tot N = 66									
n = 30									
SUM =	906			902668.5					
SUM sq. =	820836			4422					
SUMsq/n=	27361.2			204.1313	201				
		K =	75222.38						
		H =	3.131283						
correction for ties									
	T =	6	6	120	24	6	97290		
		=	97452						
	N = 66								
		287430							
		coeff. =	0.660954						
				corrected H					
				=	4.73752				

	THE RANKS AS AWARDED TO THE REPS. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	50	20	50	16	30	20	50	6	9		
7	13.5	20	50	7	13.4	3	2	12	26		
20	50	1	1	16	30	20	50	20	50		
20	50	20	50	8	17.5	20	50	6	9		
20	50	12	26	5	5.5	20	50	20	50		
10	22.5	8	17.5	20	50			20	50		
15	28	16	30	20	50			20	50		
6	9	20	50			n = 5		7	13.5		
20	50	6	9				202	8	17.5		
20	50	4	3.5	n = 7			40804				
20	50	20	50		196.4		8160.8				
18	33	11	24		38573			n = 9			
6	9	7	13.5		5510.42				275		
20	50	10	22.5						75625		
20	50	20	50						8402.78		
20	50										
17	32										
20	50	n = 15									
20	50		447			Ranks	Freq.	R. of Rank			
20	50		199809.00			1	1	1			
9	20.5		13320.6			3	1	2			
12	26					4	2	3.5			
5	5.5					5	2	5.5			
4	3.5					6	5	9			
20	50					7	4	13.5			
20	50					8	4	17.5			
9	20.5					9	2	20.5			
20	50					10	2	22.5			
8	17.5					11	1	24			
20	50					12	3	26			
						15	1	28			
tot N = 66						16	3	30			
n = 30						17	1	32			
SUM =	1090.5			900411.3		18	1	33			
SUM sq. =	1189190			4422		20	33	50			
SUMsq/n=	39639.68			203.6208	201						
		K =	75034.28								
		H =	2.620829								
correction for ties											
	T =	6	6	120	60	60	6	6	24	24	35904
		=	36216								
	N = 66										
		287430									
		coeff. =	0.874001								
				corrected H							
				=	2.99866						

	THE RANKS AS AWARDED TO THE HNST. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	51.5	8	25	8	25	4	7	5	14.5		
20	51.5	6	19	4	7	20	51.5	12	34		
20	51.5	20	51.5	17	36	4	7	20	51.5		
20	51.5	20	51.5	4	7	20	51.5	20	51.5		
20	51.5	7	22	11	32	20	51.5	7	22		
20	51.5	20	51.5	20	51.5			20	51.5		
6	19	11	32	20	51.5			20	51.5		
5	14.5	20	51.5			n = 5		20	51.5		
4	7	5	14.5				168.5	2	1.5		
20	51.5	5	14.5	n = 7			28392.3				
10	30	20	51.5		210		5678.45				
11	32	13	35		44100			n = 9			
20	51.5	5	14.5		6300				329.5		
4	7	7	22						108570		
20	51.5	20	51.5						12063.4		
20	51.5										
9	28										
4	7	n = 15									
20	51.5		507.5			Ranks	Freq.	R. of Rank			
20	51.5		257556.25			2	2	1.5			
4	7		17170.42			4	9	7			
6	19					5	6	14.5			
8	25					6	3	19			
4	7					7	3	22			
2	1.5					8	3	25			
20	51.5					9	3	28			
5	14.5					10	1	30			
20	51.5					11	3	32			
9	28					12	1	34			
9	28					13	1	35			
						17	1	36			
tot N = 66						20	30	51.5			
n = 30											
SUM =	995.5			890954.8							
SUM sq. =	991020.3			4422							
SUMsq/n=	33034.01			201.4823	201						
		K =	74246.24								
		H =	0.482323								
correction for ties											
	T =	6	720	210	24	24	24	24	26970	24	
		=	28026								
	N = 66										
		287430									
		coeff. =	0.902495								
				corrected H							
				=	0.53443						

	THE RANKS AS AWARDED TO THE BKUP. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
5	24	20	58	4	15	5	37.5	4	15		
4	15	2	5	6	31.5	1	1.5	9	45		
4	15	1	1.5	10	47	20	58	20	58		
6	31.5	20	58	20	58	20	58	7	37.5		
20	58	6	31.5	6	31.5	20	58	4	15		
4	15	5	24	20	58			4	15		
9	45	12	48	4	15			20	58		
3	8.5	5	24			n = 5		8	41.5		
20	58	7	37.5				213	2	5		
20	58	6	31.5	n = 7			45369				
7	37.5	20	58		256		9073.8				
4	15	6	31.5		65536			n = 9			
5	24	4	15		9362.29				290		
20	58	8	41.5						84100		
20	58	5	24						9344.44		
6	31.5										
8	41.5										
16	49	n = 15									
5	24		489			Ranks	Freq.	R. of Rank			
2	5		239121.00			1	2	1.5			
7	37.5		15941.4			2	5	5			
8	41.5					3	2	8.5			
9	45					4	11	15			
3	37.5					5	7	24			
2	5					6	8	31.5			
6	31.5					7	4	37.5			
4	15					8	4	41.5			
20	58					9	3	45			
2	5					10	1	47			
20	58					12	1	48			
						16	1	49			
tot N = 66						20	17	58			
n = 30											
SUM =	1005.5			929075.3							
SUM sq. =	1011030			4422							
SUMsq/n=	33701.01			210.103	201						
		K =	77422.94								
		H =	9.102954								
correction for ties											
	T =	6	120	6	1320	336	504	60	60	24	4896
		=	7332								
	N = 66										
		287430									
		coeff. =	0.974491								
				corrected H							
				=	9.34124						

	THE RANKS AS AWARDED TO THE RCMN. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	43.5	20	43.5	17	17	20	43.5	20	43.5		
20	43.5	20	43.5	9	6.5	20	43.5	16	16		
20	43.5	1	1	18	18	20	43.5	20	43.5		
20	43.5	20	43.5	20	43.5	20	43.5	20	43.5		
20	43.5	10	8.5	20	43.5	20	43.5	20	43.5		
12	11	20	43.5	5	3			20	43.5		
14	13.5	15	15	20	43.5			20	43.5		
20	43.5	20	43.5			n = 5		20	43.5		
20	43.5	8	8				217.5	20	43.5		
20	43.5	20	43.5	n = 7			47306.3				
20	43.5	20	43.5		175		9461.25				
19	19.5	19	19.5		30625			n = 9			
20	43.5	6	4		4375				364		
20	43.5	3	2						132496		
20	43.5	20	43.5						14721.8		
20	43.5										
11	10										
20	43.5	n = 15									
20	43.5		406			Ranks	Freq.	R. of Rank			
20	43.5		164836.00			1	1	1			
20	43.5		10989.07			3	1	2			
10	8.5					5	1	3			
14	13.5					6	1	4			
9	6.5					8	1	5			
20	43.5					9	2	6.5			
20	43.5					10	2	8.5			
20	43.5					11	1	10			
20	43.5					12	1	11			
13	12					13	1	12			
20	43.5					14	2	13.5			
						15	1	15			
tot N = 66						16	1	16			
n = 30						17	1	17			
SUM =	1051.5			916826		18	1	18			
SUM sq. =	1105652			4422		19	2	19.5			
SUMsq/n=	36855.08			207.3329	201	20	46	43.5			
		K =	76402.17								
		H =	6.332889								
correction for ties											
	T =	6	6	6	6	97290					
		=	97314								
	N = 66										
		287430									
		coeff. =	0.661434								
				corrected H							
				=	9.57448						

THE RANKS AS AWARDED TO THE LYTY. FACTOR.

ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	39	20	39	20	39	20	39	20	39		
20	39	20	39	14	6.5	20	39	20	39		
20	39	20	39	19	11	20	39	20	39		
20	39	20	39	7	1	20	39	20	39		
20	39	10	3	20	39	20	39	20	39		
11	4.5	20	39	20	39			20	39		
18	9.5	20	39	20	39			20	39		
20	39	20	39			n = 5		20	39		
20	39	20	39				195	20	39		
20	39	20	39	n = 7			38025				
20	39	20	39		174.5		7605				
20	39	20	39		30450.3			n = 9			
20	39	20	39		4350.04				351		
20	39	18	9.5						123201		
20	39	20	39						13689		
20	39										
20	39										
9	2	n = 15									
20	39		519.5			Ranks	Freq.	R. of Rank			
20	39		269880.25			7	1	1			
20	39		17992.02			9	1	2			
20	39					10	1	3			
15	8					11	2	4.5			
11	4.5					14	2	6.5			
20	39					15	1	8			
20	39					18	2	9.5			
20	39					19	1	11			
20	39					20	55	39			
14	6.5										
20	39										
tot N = 66											
n = 30											
SUM =	971			900769							
SUM sq. =	942841			4422							
SUMsq/n=	31428.03			203.7017	201						
		K =	75064.09								
		H =	2.701725								
correction for ties											
	T =	6	6	6	157410						
		=	157428								
	N = 66										
		287430									
		coeff. =	0.452291								
				corrected H							
				=	5.97342						

	THE RANKS AS AWARDED TO THE INFO. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	48	20	48	9	20.5	20	48	7	12.5		
20	48	20	48	8	16.5	20	48	17	29		
20	48	1	1	11	25	20	48	20	48		
20	48	20	48	6	10.5	20	48	20	48		
5	7.5	3	3.5	4	5	20	48	20	48		
8	16.5	6	10.5	20	48			20	48		
8	16.5	13	27	20	48			20	48		
20	48	20	48			n = 5		9	20.5		
20	48	20	48				240	20	48		
20	48	20	48	n = 7			57600				
8	16.5	20	48		173.5		11520				
12	26	15	28		30102.3			n = 9			
20	48	8	16.5		4300.32				350		
20	48	5	7.5						122500		
20	48	20	48						13611.1		
20	48										
10	23										
20	48	n = 15									
20	48		478			Ranks	Freq.	R. of Rank			
20	48		228484.00			1	1	1			
8	16.5		15232.27			2	1	2			
5	7.5					3	2	3.5			
10	23					4	1	5			
5	7.5					5	4	7.5			
2	2					6	2	10.5			
20	48					7	2	12.5			
7	12.5					8	6	16.5			
20	48					9	2	20.5			
3	3.5					10	3	23			
10	23					11	1	25			
						12	1	26			
tot N = 66						13	1	27			
n = 30						15	1	28			
SUM =	969.5			911936.5		17	1	29			
SUM sq. =	939930.3			4422		20	37	48			
SUMsq/n=	31331.01			206.2272	201						
		K =	75994.71								
		H =	5.227158								
correction for ties											
	T =	6	60	6	6	210	6	24	50616		
		=	50934								
	N = 66										
		287430									
		coeff. =	0.822795								
				corrected H							
				=	6.35293						

	THE RANKS AS AWARDED TO THE LSTD. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	41.5	20	41.5	19	15.5	20	41.5	20	41.5		
20	41.5	20	41.5	18	13.5	20	41.5	19	15.5		
20	41.5	20	41.5	20	41.5	20	41.5	20	41.5		
20	41.5	20	41.5	9	3.5	20	41.5	20	41.5		
20	41.5	10	5.5	20	41.5	20	41.5	20	41.5		
20	41.5	20	41.5	20	41.5			20	41.5		
20	41.5	20	41.5	20	41.5			20	41.5		
20	41.5	20	41.5			n = 5		5	2		
20	41.5	9	3.5				207.5	20	41.5		
20	41.5	20	41.5	n = 7			43056.3				
20	41.5	20	41.5		198.5		8611.25				
15	10	18	13.5		39402.3			n = 9			
20	41.5	20	41.5		5628.89				308		
20	41.5	15	10						94864		
20	41.5	20	41.5						10540.4		
20	41.5										
14	8										
17	12	n = 15									
20	41.5		489			Ranks	Freq.	R. of Rank			
20	41.5		239121.00			4	1	1			
20	41.5		15941.4			5	1	2			
20	41.5					9	2	3.5			
11	7					10	2	5.5			
10	5.5					11	1	7			
4	1					14	1	8			
20	41.5					15	3	10			
20	41.5					17	1	12			
20	41.5					18	2	13.5			
15	10					19	2	15.5			
20	41.5					20	50	41.5			
tot N = 66											
n = 30											
SUM =	1008			895089.4							
SUM sq. =	1016064			4422							
SUMsq/n=	33868.8			202.4173	201						
		K =	74590.79								
		H =	1.417333								
correction for ties											
	T =	6	6	24	6	6	124950				
		=	124998								
	N = 66										
		287430									
		coeff. =	0.565118								
				corrected H							
				=	2.50803						

	THE RANKS AS AWARDED TO THE INTR. FACTOR.										
ENGINEERING		PROCESS		PRINTING & PKG		TEXTILES		SERVICES			
20	46	20	46	18	23.5	20	46	20	46		
20	46	20	46	17	21.5	20	46	18	23.5		
20	46	1	2	12	17.5	20	46	20	46		
20	46	20	46	20	46	20	46	20	46		
20	46	3	4	10	15.5	20	46	6	6		
7	9.5	20	46	20	46			20	46		
7	9.5	20	46	20	46			20	46		
20	46	20	46			n = 5		20	46		
20	46	20	46				230	20	46		
20	46	7	9.5	n = 7			52900				
20	46	20	46		216		10580				
17	21.5	14	19		46656			n = 9			
20	46	9	13.5		6665.14				351.5		
6	6	9	13.5						123552		
20	46	20	46						13728		
7	9.5										
19	25										
10	15.5	n = 15									
20	46		475.5			Ranks	Freq.	R. of Rank			
20	46		226100.25			1	3	2			
20	46		15073.35			3	1	4			
1	2					6	3	6			
12	17.5					7	4	9.5			
6	6					8	1	12			
1	2					9	2	13.5			
20	46					10	2	15.5			
8	12					12	2	17.5			
20	46					14	1	19			
16	20					16	1	20			
20	46					17	2	21.5			
						18	2	23.5			
tot N = 66						19	1	25			
n = 30						20	41	46			
SUM =	938			904495.8							
SUM sq. =	879844			4422							
SUMsq/n=	29328.13			204.5445	201						
		K =	75374.65								
		H =	3.544516								
correction for ties											
	T =	24	24	60	6	6	6	6	6	68880	
		=	69018								
	N = 66										
		287430									
		coeff. =	0.759879								
				corrected H							
				=	4.66458						

APPENDIX 4

RANKED FACTORS AND THE AWARDED RANKS

ORGANISATIONS	Priz	Qlty	Ddte	Mtod	Fnce	Cpst	Mgte	Tkce	Smtk	Size	Golk	Pind	Reps	Hnst	Bkup	Rcmn	Lyty	Info	Lstd	Intr
Engineering	1	2	3	12	10	9	7	4	16	17	6	14	15	8	5	19	20	11	18	13
Process	2	1	3	11	9	6	7	4	18	17	12	16	10	8	5	14	20	13	19	15
Print. & Packaging	2	1	3	11	16.5	8	13.5	9	18	12	4	19	10	7	5	13.5	16.5	6	20	15
Textiles	1	2	3	20	8.5	4	11	6.5	20	20	8.5	20	10	6.5	5	20	20	20	20	20
Services	2	1	3	10	14	9	8	5	16	18	12	17	6	7	4	19	20	11	14	14
$R =$	8	7	15	64	58	36	46.5	28.5	88	84	42.5	86	51	36.5	24	85.5	96.5	61	91	77
$R^2 =$	64	49	225	4096	3364	1296	2162	812	7744	7056	1806	7396	2601	1332	576	7310	9312	3721	8281	5929
H is the total of R^2																				
H = 75133.5																				
75133.5																				
114.33																				
901602																				
2100																				
315																				
114.33																				

Eng	1	2	3	12	10	9	7	4	16	17	6	14	15	8	5	19	20	11	18	13
Process	2	1	3	11	9	6	7	4	18	17	12	16	10	8	5	14	20	13	19	15
Print	2	1	3	11	16.5	8	13.5	9	18	12	4	19	10	7	5	13.5	16.5	6	20	15
Textile	1	2	3	16	8.5	4	11	6.5	16	16	8.5	16	10	6.5	5	16	16	16	16	16
Service	2	1	3	10	14	9	8	5	16	18	12	17	6	7	4	19	20	11	14	14
Rj	8	7	15	60	58	36	46.5	28.5	84	80	42.5	82	51	36.5	24	81.5	92.5	57	87	73
M	52.5																			
Corrections for ties		Eng	0																	
		Process	0																	
		Print	1																	
		Textile	61																	
		Service	2																	
		Sum	64																	
(Rj-M)	-44.5	-45.5	-37.5	7.5	5.5	-16.5	-6	-24	31.5	27.5	-10	29.5	-1.5	-16	-28.5	29	40	4.5	34.5	20.5
(Rj-M)^2	1980.25	2070.3	1406.3	56.25	30.25	272.3	36	576	992.3	756.25	100	870.25	2.25	256	812.25	841	1600	20.25	1190.25	420.25
S	14288.50																			
W	0.87633																			
Chisquare	83.251																			

APPENDIX 5

APPENDIX 6

* RULE LIST

[1] ACQUIRE-ONE-YR-VALUES

!!! !!! !!!! !!!.!!

&*&* W E L C O M E *&*&

TO

T H E E X P E R T S Y S T E M S (EsfVS)

THAT ASSESSES THE FINANCIAL POSITION OF POTENTIAL VENDOR(S).

This program is designed to be used by those in the purchasing function.

It calculates financial ratios which it uses in determining the financial background of a potential vendor(s).

The ESfVS system analyses three years' data before providing a credible conclusion. It can also provide sound judgement base on only two years' figures.

Press ....(ENTER) .... to continue.

COL : SURR White on Blue
COL : 0,0 White on Blue

AND DO: Yes/No Question

YOU SHOULD ENTER FIGURES AS THEY ARE REQUIRED, STARTING FROM THE BALANCE SHEET OF YEAR ONE, AND THEN YEAR TWO, AND FINALLY YEAR THREE.

PLEASE FOLLOW THE INSTRUCTIONS AS THEY APPEAR.
***** NOW, START BY PRESSING Y, OK? *****

. COL : SURR White on Blue
. COL : 0,0 White on Blue

\+ AND [40] YRONECURRENTASSETS
\+ AND [41] YRONECURRENTLIABILITIES
\+ AND [43] YRONESTOCKVALUE
\+ AND [42] YRONELOANCAPITAL
\+ AND [44] YRONETOTALFINANCE

[2] ACQUIRE-THIRD-YEAR-VALUES
\+ IF [18] THIRDYRCURASS
\+ AND [17] THIRDYRCULIAB
\+ AND [20] THIRDYRSTOCK
\+ AND [19] THIRDYRLOAN
\+ AND [21] THIRDYRTOTFUND

[3] ACQUIRE-YEARTWO-VALUES
\+ IF [34] YR2CURASS
\+ AND [33] YR2CULIAB
\+ AND [38] YR2STOCK
\+ AND [35] YR2LOAN
\+ AND [39] YR2TOTFUND

[4] BETA3RESULTS
IF DO: Test Expression
YER3CURATIO>YEAR2CURATIO
AND DO: Test Expression
YER3QKRATIO>YR2QKRATIO
AND DO: Test Expression
YER3BOROWING<YR2BORROWING

[10] GOOD FINANCIAL BACKGROUND
+ IF [7] FIRM HAS THE DESIRED FINANCIAL PROFILE
F AND DO: Display Form

!! GOOD FINANCIAL BACKGROUND !!

%%
% %
THE FINANCIAL RATIOS FOR THE THREE YEARS' FIGURES MEET THE SET REQUIREMENTS %
% %
%%

THE RATIOS ARE:

First Year
Current Ratio = [FRSTC]
Quick Ratio = [FTACI]
Borrowing Level = [BORRO]

Second Year
Current Ratio = [YEAR2]
Quick Ratio = [YR2QK]
Borrowing Level = [YR2BO]

Third Year
Current Ratio = [YER3C]
Quick Ratio = [YER3Q]
Borrowing Level = [YER3B]

COL : SURR White on Blue
COL : 0,0 White on Blue

```
OUT : 11,16,22,2
    FRSTCRAT
OUT : 12,16,22,2
    FTACID
OUT : 13,18,24,2
    BORROWING
OUT : 16,16,22,2
    YEAR2CURATIO
OUT : 17,16,22,2
    YR2QKRATIO
OUT : 18,18,24,2
    YR2BORROWING
OUT : 21,16,22,2
    YER3CURATIO
OUT : 22,16,22,2
    YER3QKRATIO
OUT : 23,18,24,2
    YER3BOROWING
```

```
+ OR  [  6] FIRM HAS IMPROVING RESULTS
  AND       DO: Conclusion Display

F OR        DO: Display Form
```

```
*****************************************************************************
THE RATIOS ON WHICH THE ASSESSMENT IS BASED ARE
BELOW THE REQUIRED STANDARD, THEREFORE THE
FIRM'S FINANCIAL POSITION IS NOT ADEQUATE FOR
OUR PURPOSE
*****************************************************************************

              THE CALCULATED FINANCIAL RATIOS ARE:
                              FIRST YEAR RESULTS;
                                . CURRENT RATIO    = [FRSTCRAT]
                                . QUICK RATIO      = [FTACID ]
                                . LEVEL OF BORROWING = [BORROWIN]
                              SECOND YEAR RESULTS;
                                . CURRENT RATIO    = [YEAR2CUR]
                                . QUICK RATIO      = [YR2QKRAT]
                                . LEVEL OF BORROWING = [YR2BORRO]
                              THIRD YEAR RESULTS;
                                . CURRENT RATIO    = [YER3CURA]
                                . QUICK RATIO      = [YER3QKRA]
                                . LEVEL OF BORROWING = [YER3BORO]
```

Press...ENTER...to Continue !

[5] BORROWING
IF DO: Assign Variable
BORROWING:=YRONELOANCAPITAL/YRONETOTALFINANCE

[6] FIRM HAS IMPROVING RESULTS
+ IF [11] NOT GOOD-FIRST-YEAR-FIN-RATIOS

AND DO: Yes/No Question

THE FIRST YEAR RATIOS ARE NOT ADEQUATE FOR OUR PURPOSE. THE SYSTEM WILL NOW ANALYSE TWO YEARS' DATA. DO YOU WISH THE SYSTEM TO PROVIDE YOU WITH A RECOMMENDATION BASED ON ONLY TWO YEARS' FIGURES?

COL : SURR White on Blue
COL : 0,0 White on Blue

+ AND [12] GOOD-SECOND-YEAR-FIN-RATIOS
+ AND [13] GOOD-THIRD-YEAR-FIN-RATIOS
+ AND [4] BETA3RESULTS

[7] FIRM HAS THE DESIRED FINANCIAL PROFILE
+ IF [11] GOOD-FIRST-YEAR-FIN-RATIOS
+ AND [12] GOOD-SECOND-YEAR-FIN-RATIOS
+ AND [13] GOOD-THIRD-YEAR-FIN-RATIOS

[8] FRSTCRAT
IF DO: Assign Variable
FRSTCRAT:=YRONECURRENTASSETS/YRONECURRENTLIABILITIES

[9] FTACID
IF DO: Assign Variable

FTACID:=(YRONECURRENTASSETS-YRONESTOCKVALUE)/YRONECURRENTLIABILITIES

```
COL : SURR      White on Blue
COL : 0,0       White on Blue


OUT : 13,64,73,2
   FRSTCRAT
OUT : 14,64,73,2
   FTACID
OUT : 15,64,73,2
   BORROWING
OUT : 17,64,73,2
   YEAR2CURATIO
OUT : 18,64,73,2
   YR2QKRATIO
OUT : 19,64,73,2
   YR2BORROWING
OUT : 21,64,73,2
   YER3CURATIO
OUT : 22,64,73,2
   YER3QKRATIO
OUT : 23,64,73,2
   YER3BOROWING


[ 11] GOOD-FIRST-YEAR-FIN-RATIOS
      + IF   [  1] ACQUIRE-ONE-YR-VALUES
      +  AND [ 22] YEAR-ONE-CURRENT-RATIO
      +  AND [ 24] YEAR-ONE-QUICK-RATIO
      +  AND [ 23] YEAR-ONE-GEARING


[ 12] GOOD-SECOND-YEAR-FIN-RATIOS
      + IF   [  3] ACQUIRE-YEARTWO-VALUES
      +  AND [ 26] YEARTWO-CURRENT-RATIO
      +  AND [ 28] YEARTWO-QUICK-RATIO
      +  AND [ 27] YEARTWO-GEARING


[ 13] GOOD-THIRD-YEAR-FIN-RATIOS
      + IF   [  2] ACQUIRE-THIRD-YEAR-VALUES
      +  AND [ 14] THIRDYEAR-CURRENT-RATIO
      +  AND [ 16] THIRDYEAR-QUICK-RATIO
      +  AND [ 15] THIRDYEAR-GEARING
```

```
[ 14] THIRDYEAR-CURRENT-RATIO
      + IF    [ 30] YER3CURATIO
        AND       DO: Test Expression
                  YER3CURATIO>=0.8

[ 15] THIRDYEAR-GEARING
      + IF    [ 29] YER3BOROWING
        AND       DO: Test Expression
                  YER3BOROWING<=0.6

[ 16] THIRDYEAR-QUICK-RATIO
      + IF    [ 31] YER3QKRATIO
        AND       DO: Test Expression
                  YER3QKRATIO>=0.5

[ 17] THIRDYRCULIAB
        IF        DO: Assign Variable
                  THIRDYRCULIAB:=0
      W   AND       DO: Display Form
                WPOS: 2,15,10,50
```

ENTER THE VALUES OF THE CURRENT LIABILITY **<THIRDYRCULIAB >**

```
                COL : SURR      White on Blue
                COL : 0,0       White on Blue
                IN  : 5,0,27,0  Blue on Gray
                  THIRDYRCULIAB

[ 18] THIRDYRCURASS
        IF        DO: Assign Variable
                  THIRDYRCURASS:=0
      W   AND       DO: Display Form
                WPOS: 2,15,10,50
```

NOTE: ***** NOW, ENTER THE THIRD YEAR'S DATA ***** **WHAT IS THE CURRENT ASSET?** **<THIRDYRCURASS >**

```
                COL : SURR      White on Blue
                COL : 0,0       White on Blue
                IN  : 3,0,27,0  Blue on Gray
                  THIRDYRCURASS
```

[19] THIRDYRLOAN
IF DO: Assign Variable
THIRDYRLOAN:=0
W AND DO: Display Form
WPOS: 2,15,10,50

HOW MUCH IS THE LOAN CAPITAL
<THIRDYRLOAN >

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 4,0,27,0 Blue on Gray
THIRDYRLOAN

[20] THIRDYRSTOCK
IF DO: Assign Variable
THIRDYRSTOCK:=0
W AND DO: Display Form
WPOS: 2,15,10,50

<THIRDYRSTOCK >
ENTER THE VALUE OF STOCK

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 3,0,24,0 Blue on Gray
THIRDYRSTOCK

[21] THIRDYRTOTFUND
IF DO: Assign Variable
THIRDYRTOTFUND:=0
W AND DO: Display Form
WPOS: 2,15,10,50

WHAT IS THE TOTAL SUM OF CAPITAL EMPLOYED?
<THIRDYRTOTFUND >

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 7,0,28,0 Blue on Gray
THIRDYRTOTFUND

```
[ 22] YEAR-ONE-CURRENT-RATIO
     + IF   [  8] FRSTCRAT
       AND       DO: Test Expression
                 FRSTCRAT>=0.8

[ 23] YEAR-ONE-GEARING
     + IF   [  5] BORROWING
       AND       DO: Test Expression
                 BORROWING<=0.6

[ 24] YEAR-ONE-QUICK-RATIO
     + IF   [  9] FTACID
       AND       DO: Test Expression
                 FTACID>=0.5

[ 25] YEAR2CURATIO
       IF        DO: Assign Variable
                 YEAR2CURATIO:=YR2CURASS/YR2CULIAB

[ 26] YEARTWO-CURRENT-RATIO
     + IF   [ 25] YEAR2CURATIO
       AND       DO: Test Expression
                 YEAR2CURATIO>=0.8

[ 27] YEARTWO-GEARING
     + IF   [ 32] YR2BORROWING
       AND       DO: Test Expression
                 YR2BORROWING<=0.6

[ 28] YEARTWO-QUICK-RATIO
     + IF   [ 36] YR2QKRATIO
       AND       DO: Test Expression
                 YR2QKRATIO>=0.5

[ 29] YER3BOROWING
       IF        DO: Assign Variable
                 YER3BOROWING:=THIRDYRLOAN/THIRDYRTOTFUND
```

[30] YER3CURATIO
IF DO: Assign Variable
YER3CURATIO:=THIRDYRCURASS/THIRDYRCULIAB

[31] YER3QKRATIO
IF DO: Assign Variable
YER3QKRATIO:=(THIRDYRCURASS-THIRDYRSTOCK)/THIRDYRCULIAB

[32] YR2BORROWING
IF DO: Assign Variable
YR2BORROWING:=YR2LOAN/YR2TOTFUND

[33] YR2CULIAB
IF DO: Assign Variable
YR2CULIAB:=0
W AND DO: Display Form
WPOS: 2,15,10,50

ENTER THE VALUES OF THE CURRENT LIABILITY.
<YR2CULIAB >

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 3,0,23,0 Blue on Gray
YR2CULIAB

[34] YR2CURASS
IF DO: Assign Variable
YR2CURASS:=0
W AND DO: Display Form
WPOS: 2,15,10,50

NOTE: * NOW ENTER SECOND YEAR'S DATA *****
<YR2CURASS >
WHAT IS THE VALUE OF THE CURRENT ASSETS?

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 2,0,20,0 Blue on Gray
YR2CURASS

[35] YR2LOAN
IF DO: Assign Variable
YR2LOAN:=0
W AND DO: Display Form
WPOS: 2,15,10,50

<YR2LOAN >
WHAT IS THE AMOUNT OF LOAN?

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 2,0,29,0 Blue on Gray
YR2LOAN

[36] YR2QKRATIO
IF DO: Assign Variable
YR2QKRATIO:=(YR2CURASS-YR2STOCK)/YR2CULIAB

[37] YR2RESULTS
+ IF [25] YEAR2CURATIO
+ AND [36] YR2QKRATIO
+ AND [32] YR2BORROWING

[38] YR2STOCK
IF DO: Assign Variable
YR2STOCK:=0
W AND DO: Display Form
WPOS: 2,15,10,50

ENTER THE VALUE OF STOCK
<YR2STOCK >

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 2,0,23,0 Blue on Gray
YR2STOCK

[39] YR2TOTFUND
IF DO: Assign Variable
YR2TOTFUND:=0
W AND DO: Display Form
WPOS: 2,15,10,50

HOW MUCH CAPITAL WAS EMPLOYED?
<YR2TOTFUND >

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 3,0,20,0 Blue on Gray
YR2TOTFUND

[40] YRONECURRENTASSETS
IF DO: Assign Variable
YRONECURRENTASSETS:=0
F AND DO: Display Form

N O W * *****

ENTER THE VALUES IN THE SPACES PROVIDED

ENTER 0 (ie ZERO) WHERE NO DATA EXISTS

BEGINNING WITH THE FIRST YEAR'S DATA...

WHAT IS THE VALUE OF THE CURRENT ASSETS?
<YRONECURRENTASSETS >

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 24,40,70,0 Blue on Gray
YRONECURRENTASSETS

[41] YRONECURRENTLIABILITIES
IF DO: Assign Variable
YRONECURRENTLIABILITIES:=0

W AND DO: Display Form
WPOS: 2,15,10,50

<YRONECURRENTLIABILITIES >
ENTER THE VALUES OF THE CURRENT LIABILITY

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 3,0,33,0 Blue on Gray
YRONECURRENTLIABILITIES

[42] YRONELOANCAPITAL
IF DO: Assign Variable
YRONELOANCAPITAL:=0
W AND DO: Display Form
WPOS: 2,15,10,50

ENTER THE AMOUNT OF LOAN CAPITAL
<YRONELOANCAPITAL >

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 3,0,28,0 Blue on Gray
YRONELOANCAPITAL

[43] YRONESTOCKVALUE
IF DO: Assign Variable
YRONESTOCKVALUE:=0
W AND DO: Display Form
WPOS: 2,15,10,50

WHAT IS THE STOCK VALUE?
<YRONESTOCKVALUE >

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 2,0,22,0 Blue on Gray
YRONESTOCKVALUE

[44] YRONETOTALFINANCE
IF DO: Assign Variable
YRONETOTALFINANCE:=0
W AND DO: Display Form
WPOS: 2,15,10,50

WHAT IS THE TOTAL CAPITAL EMPLOYED?
<YRONETOTALFINANCE >

COL : SURR White on Blue
COL : 0,0 White on Blue
IN : 3,0,32,0 Blue on Gray
YRONETOTALFINANCE

[45] ***CRYSTAL MASTER RULE***

+IF [10] **GOOD FINANCIAL BACKGROUND**

APPENDIX.

HOW TO RUN THE TEST PROGRAM

To run the program, one must have Crystal 4.5 in his or her computer system. If not, it should be installed using DOS commands. This is because this version of Crystal runs only on DOS. Then, switch the computer on and go into the Crystal4 directory. At the <CRYSTAL4> prompt, enter CR to execute the Crystal program. Then choose the FILE option from the MENU and press <enter>. Choose LOAD Knowledge Base option. Then highlight the name of the knowledge base file (which is FINALRL) and press <enter>. At the menu prompt, choose the RUN option. From this point onwards, follow the instructions as they appear on your computer screen.

APPENDIX 7

ASTON
BUSINESS
SCHOOL

Ref. AST/JED/BJ12

Dear sir,

USER REQUIREMENTS / PROGRAMME UPDATE:

You may recall that we contacted you in 1994 to help us in our effort to develop an Expert System which organisations can use in solving the problem of vendor selection. We wish to thank you for taking your time and completing our survey questionnaire at the time. Following your valuable response, a prototype Expert System, **ESfVS** has been developed to address one of the factors listed in the previous questionnaire...Financial Background of the vendor(s).

A list of organisations has been drawn up, and I am pleased to inform you that you are one of those who have been selected to test the system. After the test, we will install the system for you at no cost at all. All we ask in return is your valued opinion. This will then enable us to make well informed decisions and modifications, if need be, in order to further develop a system capable of helping UK industries.

Enclosed is a questionnaire which we would be very grateful if could complete to advise us of what and how you would like the program to perform.

Thank you once again for your support.

Yours Sincerely,

Ben. OBIDIGBO

Aston University, Aston Triangle, Birmingham B4 7ET, UK.
Telephone 021-359 3611. Telex 336997 UNIAST G. Fax 021-333 5620. Electronic Mail: (JANET) BUSINESS@UK.AC.ASTON

EXPERT SYSTEMS FOR VENDOR SELECTION [ESfVS].

SYSTEM TESTING SURVEY QUESTIONNAIRE

Organisation ....
Address ....
....
....

Job Title ....

Name ....

1). How many employees are you responsible for? [Please Tick the Appropriate Box(es)]

None[ ]. 1[ ]. 2/3[ ]. 4-6[ ]. 7-10[ ]. 11-20[ ]. 21-30[ ]. >30[ ].

2). How many computers are used by your department?

None[ ]. 1[ ]. 2/3[ ]. 4-6[ ]. 7-10[ ]. 11-20[ ]. 21-30[ ]. >30[ ].

3). Is there any PC in your department that nobody except you would use?

Yes[ ]. No[ ].

4). If this Expert System is installed to your organisation, how many employees will be using it?

None[ ] Only Me[ ]. 2-3[ ]. 4-6[ ]. 7-10[ ]. 11-20[ ]. 21-30[ ]. All[ ].

5). What do you hope to achieve by using ESfVS system?

Speed of processing [ ].
Consistency of results [ ].
Performance Efficiency [ ].
Cost Reduction [ ].

5b). others ....
....
....
....

6). How would you describe the reaction of your organisation towards using this new program?

Hostile[ ]. Delightful[ ]. Lukewarm[ ]. Reluctant[ ].

7). Do you usually assess the Financial Background of a potential supplier(s)?

Yes[ ]. No[ ].

8). Are you familiar with these ratios and how they are derived?

. Current Ratio,.. Yes[ ]. No[ ].
. Quick Ratio / Acid Test,.. Yes[ ]. No[ ].
. Borrowing Percentage,.. Yes[ ]. No[ ].
. Profit Ratio,.. Yes[ ]. No[ ].

9). Have you come across any other system that determines Vendor's Financial Background?

Yes[ ] No[ ].

10). If Yes to question 9,

what is the brand name of the system? ....
when did you use or observe the system? ....
how does it compare with ESfVS? ....
....
....

11). Is the ESfVS user friendly?

1 [ ] 2 [ ] 3 [ ] 4 [ ] 5 [ ]
Poor Very Good.

12). Does ESfVS help you to understand the difference between Expert Systems and other computer programs?

Yes[ ]. No[ ].

13). To what extent has this system improved your knowledge of Expert Systems?

90-100%[ ] 70-89%[ ] 50-69%[ ] 35-49%[ ] 20-34%[ ] 1-20%[ ] Not at All[ ]

14). What other feature(s) would you like to be present in ESfVS?

....
....
....
....
....

15). How much would you be prepared to pay for a system that performs vendor selection tasks?

£3000-£3500[ ] £2000-£2999[ ] £1000-£1999[ ] £500-£999[ ] £300-£499[ ] £100-£299[ ]

16). Remarks ....
....