Factors Affecting End-User Computing Sophistication in Small Business

ZULKHAIRI DAHALIN

Doctor of Philosophy

ASTON UNIVERSITY

May 2000

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SUMMARY

This thesis describes research on End-User Computing (EUC) in small business in an environment where no Information Systems (IS) support and expertise are available. The research aims to identify the factors that contribute to EUC Sophistication and understand the extent small firms are capable of developing their own applications. The intention is to assist small firms to adopt EUC, encourage better utilisation of their IT resources and gain the benefits associated with computerisation.

The factors examined are derived inductively from previous studies where a model is developed to map these factors with the degree of sophistication associated with IT and EUC. This study attempts to combine the predictive power of quantitative research through surveys with the explanatory power of qualitative research through action-oriented case study. Following critical examination of the literature, a survey of IT Adoption and EUC was conducted. Instruments were then developed to measure EUC and IT Sophistication indexes based on sophistication constructs adapted from previous studies using data from the survey. This is followed by an in-depth action case study involving two small firms to investigate the EUC phenomenon in its real life context. The accumulated findings from these mixed research strategies are used to form the final model of EUC Sophistication in small business.

Results of the study suggest both EUC Sophistication and the Presence of EUC in small business are affected by Management Support and Behavior towards EUC. Additionally EUC Sophistication is also affected by the presence of an EUC Champion. Results are also consistent with respect to the independence between IT Sophistication and EUC Sophistication. The main research contributions include an accumulated knowledge of EUC in small business, the Model of EUC Sophistication, an instrument to measure EUC Sophistication Index for small firms, and a contribution to research methods in IS.

Key Words:
End-User Application Development, Small Firms, IT Sophistication, Survey and Case Study in IS Research, IS Strategy

Dedication

This thesis is dedicated to my mother, Halimah, and to the dear memory of my father, Mohammed Dahlim, for all their love, support and encouragement.

To my loving wife, Sara who is the source of my inspiration and motivation, and my children Zaslan, Nina and Dalin, this thesis is also dedicated to you with a special note of thanks for your patience and sacrifices, and for being such a loving, supporting and caring family,

and also

to my brothers and sisters, Man, In, La, Li, Kak Yah, Chek, Nani and Nen, I love you all.

Give a man a fish
And you feed him for a day
Teach a man to fish
And you feed him for life.

Give a user a program
And you satisfy him for a day
Teach a user to program
And you satisfy him for life.

ACKNOWLEDGEMENT

I would like to acknowledge the following whose support has been instrumental in ensuring the successful completion of the research and this thesis. First and foremost I would like to express my utmost appreciation to my PhD supervisor, Dr. Paul Anthony Golder for his supervision of the research. His ideas and guidance have been an enormous help throughout the process from the initial selection of the subject to research and the research methods, through his critical review and examination of the results, reports, manuscripts and preparation of this thesis.

I wish to express my gratitude to *Universiti Utara Malaysia* (the University of Northern Malaysia) for providing the research grant and financial assistance to enable me to undertake this research. Likewise I am also indebted to Aston University for providing part of the research grant, Aston University-British Council Joint Scholarship Award, and other physical and material support.

This research would not have materialised without the support and participation from the small firms in Birmingham, particularly the two firms that participated in the case study. In particular I would like to thank Mr. David Pierce, the Managing Director of Britannia Heat Transfer Limited and Mr. Peter Korbar, the Regional Director of Universal Steel Tube Company Limited. I would also like to acknowledge my appreciation to all the key personnel of these two companies that have unselfishly shared information and ideas, which are critical to the success of the study.

I would also like to thank the following organisations that have helped in supporting the research. This includes Business Links Birmingham for providing useful information on small business in the West Midlands and the Birmingham Chamber of Commerce and Industry for supplying the database of small firms. The Data Management Services, Aston Business School for administration of the survey and Aston University Library Information Services for providing first class facilities for searches and inter-library loans.

Finally, I wish to thank Mr. Bernard Doherty and Dr. Dave Lawrence for their constructive comments and suggestions towards the final preparation of this thesis.

I am indeed grateful for the opportunity to work with all these great and wonderful people who have given me the inspiration, courage, and energy to complete the research and this thesis.

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CHAPTER 1. INTRODUCTION

1.0. BACKGROUND

This research was born out of personal experiences dealing with small firms and other organisations (both public and private) in an environment where limited or no support was available to assist such firms in the use of their Information Technology (IT) resources. This came from the interactions and personal observations with such firms in the last 15 years, beginning with a career the author undertook as an IT professional with an international computer manufacturer. Experiences show that under-utilisation of IT resources was a frequent phenomenon in these firms and their inability to develop even simple applications beyond the word processing routines have made the situation even worse. This phenomenon continues at present and even becomes progressively pervasive as more and more firms are adopting IT. The constant interactions with many small firms as an IT lecturer (industrial attachment supervision) and an IT consultant (IS planning and development) has confirmed this experience. The sense of frustration could be felt as these firms were struggling to adopt their IS solutions in order to support their business needs. Many were observed to fall prey to their own incompetent management and development of their IT resources, whilst many more fell victims to unscrupulous vendors and third-party sources due to the small firms' vulnerable nature.

Today, as more and more firms are adopting IT, the use of IT is no longer perceived as a luxury but rather a necessity even for the small business. As a result this proliferation of IT has brought the computerisation of business activities within reach of many small firms. This trend is likely to continue as more and more firms appreciate the potential benefits of IT to the business in terms of increased competitiveness, increased productivity, improved efficiency in activities and work processes, enhanced marketing effectiveness, better management of information and record-keeping, and improved quality of products and services. This suggests that small firms are becoming more sophisticated in their use of IT, either through the means of third-party development, acquiring off-the-shelf packages, or developing their own, or some combination of these. It is the firms' own development of applications, better known as End-User Computing (EUC), that is of interest in this thesis. From the related literature and through experience of dealing with such firms, four main reasons for studying EUC in small business were identified.

Firstly, extensive literature search showed that studies on EUC have been mainly confined to large organisations. Studies such as Raymond (1990b) and Ein-Dor and Segev (1978) showed that significant differences exist between large and small firms in terms of their structures, characteristics and organisational behavior. Attewell and Rule (1992) caution that it would be foolish to expect IS studies carried out in large firms to be applicable for the general working population, yet small firms account for more than half of the workforce employment (Joyce et al. 1996). Hence with few studies of EUC in small business, little is known regarding the extent small firms are capable of developing their own applications.

Secondly, experience with small firms shows that such firms are generally financially constrained and the hiring of external services is not within the means of many small firms. Moreover, buying ready-made packages may not always meet the business requirements and firms may be forced to tailor applications to suit their individual needs, which again could be very expensive.

Thirdly, it is difficult to find a small firm with internal IT expertise and many are forced to be dependent on external sources for their IT resources. This would again be a problem for the financially constrained firms and even if they can afford it, they would tend to depend heavily on the vendors who may have their own interests to pursue.

The fourth reason for the study of EUC in small business is that research on EUC has been largely focussed on the "non-developer" end-user type as opposed to the user-developer, where the former refers to those end-users that merely use computer application and packages developed by others. Cragg and Zinatelli (1995) for instance observed that most users in small and medium-sized enterprises are classified as "non-programming end-users", relying on packaged software and external sources for their application software. Whilst evidence of EUC in the form of user involvement, user acceptance, user competence, user development, training, etc. has been reported within the context of IT adoption, IS success, EUC satisfaction and success, very few studies have been reported focussing on user-developer in the specificity of small business.

1.1. AIMS OF THE RESEARCH

Until more studies are done in this area by extending the body of knowledge in which EUC phenomenon within the context of small firms could be better understood, small firms will face an uphill task against overcoming the anxiety and risks of adopting IT, and worse still, in developing their own applications. The research which this thesis reports therefore attempts to achieve the following aims:

i. **To study the factors that contribute to EUC Sophistication in small business; and**
ii. **to understand the extent small firms are capable of developing their own applications and achieving a higher level of EUC sophistication.**

With these aims in mind, the hope is that this research will enable small firms to comfortably embark on future IT adoption with an increase in end-user application development, and gain the benefits associated with computerisation as experienced by their larger counterparts. In order to realise this, three research questions have been formulated to support the aims. These are:

1. **To what extent small firms are capable of developing their own applications?**
2. **Are there differences between firms with different levels of IT sophistication with respect to EUC sophistication?**
3. **Is increased IT Sophistication a necessary pre-requisite for the development of EUC?**

Research hypotheses will also be formulated to support the research aims particularly to study the factors and their relationships with EUC Sophistication. They will also act as means to find answers to the research questions.

Experience shows that embarking on end-user computing (EUC) only requires a minimum of IT investment. The simple purchase of an inexpensive PC with some of the more common software bundled together are all that is required. EUC could be a starting point for developing internal expertise and becoming independent of third parties. Over time, users who are familiar with entering data and simple formulae in a spreadsheet can now integrate that with a word processor to develop mailing lists and form letters for mail shots, and migrate to a database package to generate management information reports. Later, screen forms and menus could be developed as part of a more sophisticated application to facilitate data entry for efficient record-keeping and information retrieval systems. These could possibly be done with no additional hardware or software and does not require third party intervention or specialised IS development skills. At the same time the users' own skills in end-user development may greatly be enhanced. However, without research to study the factors affecting EUC sophistication in small business, it would be difficult to provide guidelines and assist small firms to embark on EUC.

1.2. SIGNIFICANCE OF THE STUDY

End-User Computing or the development of computer applications by ordinary staff and managers is present in many of today's organisations, and this is likely to increase in the years to come (Aggarwal, 1994). EUC according to Blili et al. (1996) has now reached a level of sophistication where some end-users are capable of developing their own individual and departmental applications without the help of IS professionals. According to the authors (Blili et al., 1996) there is evidence that this is happening at present in both large and small organisations. This can be attributed to the proliferation of inexpensive microcomputers and user-friendly software (Igbaria and Zviran, 1996) in addition to the general awareness of the benefits of using IT to reduce costs, improve services and sustain competitiveness (Lees and Lees, 1987; Magal and Lewis, 1995). With effective EUC strategies, more applications could be developed that would closely match the user requirements resulting in increased operating efficiency and effective decision-making. It is not an overstatement to suggest that early in this millennium EUC will be accepted as an everyday activity in all types and sizes of businesses due to the tremendous development in this area.

It has been observed that the interest in EUC comes from the desire of end-users to get the most from their IT resources in order to support their business activities. This is made possible from the support end-users get from the internal data processing department and other end-user computing support functions. However, the support for EUC in large organisations with formal IS support is not always available within small businesses. In small firms, the desire to utilise IT resources is made more difficult by the absence of internal support and lack of internal expertise. External sources and other third party development are often too expensive and not within the means of most small firms. Small firms are often left with little choice other than to manage their own IT resources and to plan their own information systems. This has posed considerable risks of IT adoption failure that can be disastrous to a small firm. As a result small business has had to seek other alternatives in order to realise the benefits associated with computerisation.

Although there has been much research in the use of IT in small business, little is understood of EUC sophistication and the extent to which small firms are capable of developing their own applications. The research aims and questions posed earlier in the preceding section attempt to address these specific issues with the intention of understanding the factors and their effect on EUC sophistication in the small business. This understanding will hopefully assist small firms to readily adopt EUC as an alternative to IT adoption, and in the process, achieving optimal use of their IT resources.

1.3. OUTLINE OF THE RESEARCH METHODS

In order to help achieve the research aims and address the issues specified in the research questions, mixed research methods combining the survey and case study research strategies were employed. Questionnaire-based face-to-face interviews were carried out in the pre-survey stage for the pilot study. A mailed survey was carried out where the revised questionnaires were posted to the addresses of the firms appeared in a database of small businesses supplied by the Birmingham Chamber of Commerce and Industry.

For the case study, a structured IS strategy approach was incorporated in the action case component to investigate the case study firms. The investigation involved analysing the business strategy and performing IS strategy studies that includes IS planning and analysis of the business areas. The case study did not include the design of systems or the development of actual applications, as these were not within the scope of the research. The research only examined issues at the organisational level where the Unit of Analysis is the small firm. Though personal characteristics at the individual level such as education and training, EUC skills, techniques and approaches, business experience, support, responsibility, time constraints etc have been studied previously, these are not included in this study as the research aims to establish consensus at the organisational level. This is in keeping with the suggestion made by Galliers (1992) that the focus of IS research can either be in the context of Organisation or Individual, in addition to Society, Technology, Methodology or Theorem Building and Testing. In addition, Premkumar & Roberts (1999) contend that studying innovation adoption at the organisational level should not normally include individual/personal characteristics.

Whilst the survey research employed statistical analysis to analyse the quantitative data of the sample firms, the case study research used direct observation and participant-observation in a structured IS development approach to analyse the qualitative information. Accumulated evidence from these analyses was used as the main findings in answering the research questions and supporting the main aims.

1.4. SUMMARY OF RESEARCH FINDINGS AND CONTRIBUTIONS

This thesis broadly categorised the research findings into four, ie. (1) findings from critical review of the literature, (2) findings from the survey, (3) findings from the case studies, and (4) cumulative findings from both survey and case studies.

The critical examination of the literature leads to the first-cut theoretical model of factors affecting EUC Sophistication in small business. It has also contributed to the identification of end-user typology appropriate to small business and enabled the development of the conceptual measures for both EUC and IT sophistication.

Findings from the survey can be sub-divided into three, that is findings of the demography and background information, IT adoption and the presence of EUC. Demography and background information provides the structure needed to place the research on a strong foundation. The aim of studying a phenomenon within the context of small business has been met with the capturing of a valid sample of 186 small firms. The random distribution of the sample data allows statistical analysis beyond frequency counts, percentages and cross-tabulations to be done to further probe and understand the data. The questions on IT adoption found that small firms are generally IT literate which makes them potentially capable of developing their own applications. The questions on the presence of EUC indicate significant EUC activities in small business, and these findings help addressed the research questions and aims that relate to the extent small firms are capable of developing their own applications.

The case study investigation provides the opportunity to gain in-depth understanding of the EUC activities by providing useful insights into the level of EUC sophistication and the factors affecting EUC sophistication. While this has also addressed the research question and aim concerning the factors affecting EUC Sophistication and the relationships between EUC and IT Sophistication, the statistical analysis from the survey has also provided the opportunity to generalise the factors and their relationships with EUC and IT sophistication.

Findings accumulated from both the survey and case study found several factors affecting EUC Sophistication in small business. Top Management Support, Organisational Characteristics and Behavior towards EUC are three main factors found to affect EUC Sophistication in small business. Top Management Support and Behavior towards EUC are also found to affect the presence of EUC in small business. The research has also found EUC Sophistication is independent of IT Sophistication. IT Sophistication is also affected by IT Adoption and Organisational Characteristics.

This study has made a number of contributions to research and the small business. The model of the factors affecting EUC Sophistication and the sophistication measurements provide useful guidelines for firms to assess their EUC strategy in particular and IT adoption in general. Employing the mixed research strategies has not only helps generalise the findings and add insights into the EUC phenomenon, but also helps to validate the findings and explains unusual or contradictory results. Incorporating suitable IS methodology and appropriate automated tool support have also facilitate the research process and contribute to the wealth of methods available in IS research.

1.5. SUMMARY OF CONTRIBUTION TO KNOWLEDGE IN THIS AREA

The research on which this thesis is based has made a number of findings that relate to answering the research questions and addressing the main aims of the research thereby contributing to knowledge in the EUC area. These findings can be summarized based on the research questions as follows:

Research Question 1: To what extent small firms are capable of developing their own applications?

On the basis of the critical review of literature, a model of EUC sophistication in small business was created and subsequently tested through administration of a survey. Findings from the survey revealed significant development of EUC among small businesses with one in every two firms practised end-user application development. This is also consistent with findings from the case study that found a moderately sophisticated group of end-users exists in the firms being investigated with high degree of usage of the applications, larger number of applications developed by end-users, and the nature and type of applications are moderately sophisticated.

Research Question 2: Are there differences between firms with different levels of IT sophistication with respect to EUC sophistication?

Using the EUC Sophistication index and IT Sophistication index developed in this research, the hypothesis that relates IT Sophistication with EUC Sophistication found no significant relationship exists between the two. Hence the study found no differences between firms with different levels of IT Sophistication with respect to EUC Sophistication.

Research Question 3: Is increased IT Sophistication a necessary pre-requisite for the development of EUC?

The extent of the small firm's EUC capability as addressed by research question 1 and the independence between IT and EUC sophistication as addressed by research question 2 suggest that end-user application development can exists in firms with different levels of IT sophistication. Hence the study found that increased IT sophistication is not a pre-requisite for the development of EUC in small business.

1.6. OUTLINE OF THE THESIS

Findings of the research as summarised in the preceding sections are detailed in the various chapters of this thesis. This section presents summaries of these chapters as outline in this thesis and provides the general structure for the presentation of this thesis.

This first chapter describes the general background to the area of research by providing a brief background of the issues faced by small firms in relation to the adoption of IT and the presence of EUC in small business. The need to conduct EUC studies for small business is described, and the main aims and research questions formulated. To meet these aims an outline of the research methods is described as the approach taken in this study. This leads to a summary of the research findings and contributions. A specific summary of the findings that relates back to the research aims and questions is also included as summarised in the preceding section. With an outline of the thesis presented here together with the meanings of useful terms and definitions presented in the next section, this chapter provides the general introduction that cross-references other chapters in this thesis.

Having introduced the area of research, the next two chapters present detailed reviews of the main topics namely ***Small Business*** and ***End-User Computing***. Chapter 2 begins with some definitions of small business and describes the nature and characteristics of the small business. Review of related literature on IT in small business is presented and current research on IT sophistication in small business is also examined. This includes a review of the IT Sophistication Index construction that will form the basis for the formulation of the IT Sophistication measure used in the research.

Chapter 3 focuses on End-User Computing by discussing the definitions and concept of End-User Computing followed by examinations of the various theoretical constructs based on related studies. Factors identified in these studies together with the issues relevant to the small business are taken as the basis to form the initial model of EUC Sophistication in Small Business. Review of related literature on EUC Sophistication will form the basis for the formulation of the EUC Sophistication measure where the EUC Sophistication Index construct was to be developed.

Chapter 4 presents the research methods and summarises a number of research strategies that can be applied to IS research. The chapter describes the methods employed and makes justification for the survey research and case study research strategies used for the entire study. An overall research framework is presented where details of each research strategy are elaborated. The research was to be carried out in two main stages corresponds to the survey research in the first stage and the action case study research in the second stage. Research hypotheses are then formulated based on the Initial Model of EUC Sophistication in Small Business. The initial model and hypotheses are used as guidelines for the survey and design of the questionnaire.

Chapter 5 describes the analysis and results of the survey of small firms, their IT adoption and EUC presence. A detailed discussion and operationalisation of the measurement constructs for both EUC and IT sophistication is also presented. This enables the hypothesised relationships among the variables defined in the initial model to be tested. Results of the hypothesis tests are tabulated and adjustments made to the initial model to form the Revised Model of EUC Sophistication in Small Business. This revised model was to be used as a guide to help in the case study investigation. The sophistication indexes are used to identify suitable candidates to participate in the case study investigation.

Discussions on the case study investigation are presented in Chapter 6. This includes preliminary information such as computation of the sophistication indexes, research activities and interview appointments for the two firms participated in the case study. A description of the main fact-finding technique, namely the Information Engineering approach is also included. This approach enables the creation of the research database and helps in the preparation of the IT Research reports prepared for the two firms. Cases for the two firms are presented and summaries of the firm's profile, IT adoption and presence of end-user application development are discussed.

A detailed analysis of the case study results is presented in Chapter 7. This includes analysis of the cross-case results based on information gathered across the two cases using the Revised Model of EUC Sophistication as the research framework. Among the information used in the cross-case analysis includes the firms' background information, dependent variables representing the dimensions of EUC Sophistication, and the independent variables representing the factors contributing to EUC Sophistication as in the revised model. Results of the cross-case analysis are used to modify the revised model producing the final contribution of the research study, namely the Modified Model of EUC Sophistication in Small Business presented in Chapter 8.

Chapter 8 discusses the summary of the main findings of the research discussed in the previous chapters. The Modified Model of EUC Sophistication in Small Business is presented representing the cumulative findings from the survey and case study research strategies. This is followed by a discussion of the sophistication indexes. Main contributions of this study are discussed including a contribution to research methods in IS. A discussion of the implications of the study is presented covering the impact on the research methods including the adoption of the mixed strategy and the use of the strategic IS approach as part of the action case study method. The sophistication index measurements, its usefulness and stage of development are also discussed. Implication for the risks of EUC to small business is also highlighted. The chapter ends by addressing the limitations of the present study and suggesting possible future work in this area that can be built on top of this research.

Chapter 9 presents the conclusion of the thesis. The research achievements are highlighted, addressing the research questions that support the aims of the study as stated in this chapter. Summaries of the chapters that help address the research questions are presented together with highlights of the main research hypotheses. A summary of the research methods used is presented together with a summary of the main contributions. Prospects for future research directions on EUC in small business are discussed.

Finally, appendices are included at the end of the thesis as additional information to describe detailed works done in relation to the research. Appendices 1 and 3 are samples of questionnaires used in the survey and case study, whilst Appendix 2 is the Preliminary Survey Report given to the firms participated in the survey. Appendices 4 and 5 are the IT Research Report for the two firms which participated in the case study investigation, highlighting the business requirements and the firms' IS strategy as well as EUC implementation. Appendix 6 lists the Systems, IT Products, Technology and Applications used in the survey. Appendices 7 and 8 show the activity schedule and interview appointments for the case study. Appendix 9 is a source program written in Ada to perform the entity-clustering algorithm as an automated tool to assist in the formulation of the firms' IS strategy.

1.7. TERMS AND DEFINITIONS

Numerous terms, definitions and abbreviations of words have been used throughout this thesis and where available standard connotations are used to describe them. Some of these words constitute trademarks and are designated as such in this section. Others that are non-specific and ambiguous are clarified and elaborated upon when encountered in the appropriate sections or chapters. The meanings of computing terms and definitions are borrowed from several computing dictionaries including **A Glossary of Computing terms** (BCS, 1995), **The McGraw-Hill Illustrated Dictionary of Personal Computers** (Hordeski, 1995), **Information Systems Practice: The Complete Guide** (Gunton, 1993), and **Computing Terms and Acronyms: A Dictionary** (Hipgrave, 1985). Information Engineering terms are taken from **Information Engineering,** volumes 1 and 2 by James Martin (Martin, 1986a, 1986b). Other terms and definitions used throughout this thesis but not included in this section appear in the Glossary at the end of the thesis.

End-User Computing and ***Small Business*** are two terms that are central to the subject of this thesis. As such whole chapters have been devoted to them because of their significance in this study. A detailed description of ***Small Business*** is included in Chapter 2, whilst Chapter 3 discusses ***End-User Computing***. Though there is no standard definition of ***End-User Computing*** (***EUC***), the meaning of the term used in this thesis is the direct hands-on use of computing resources by end-users to support their business needs. Other more specific terms used to designate End-User Computing include ***End-User Development, User Developed Application*** and ***Business User Development***. These terms are sometimes used interchangeably with End-User Computing but they are particularly used to emphasise the active involvement of end-users in the application development work. The nature and complexity of the application, the degree of its usage, and the extent to which end-users are capable of developing the application is known as ***End-User Computing Sophistication***.

An application is an information system designed to carry out some task such as keeping accounts, editing text, maintaining a mailing list, etc. An ***application program*** is designed to meet the requirements of a particular individual or organisation, and normally developed specifically for the individual or organisation. Applications range from the computational type in which arithmetic operations predominate to the processing type in which data-handling operations are the major function. Traditionally, applications are developed by IS professionals but with the advent of End-User Computing, more and more end-users are now developing their own applications.

The term ***end-user*** refers to the person beside an ***IS professional*** who works in an organisation making use of the computing facilities and for whom information is being retrieved, or for whom information is being processed. An ***IS professional*** is a person who works within the IT environment and who normally receives formal education and training in IT, which includes people with certificates and degrees in computing and information systems.

End-User Typology is the classification of end-users according to their capability of using computers in terms of skills, method of computer use, application focus, education and training, and computer support needed. A detailed typology of end-users is elaborated in Chapter 3 and also included in the Glossary.

An ***Application Portfolio*** is the group of different types of applications identified according to their strategic importance to the firm in terms of evaluating and prioritising information systems investments. A detailed discussion of the application portfolio appears in the appropriate section of Chapter 6 and is also included in the Glossary.

Information Engineering is a structured IS development approach in which the enterprise's information strategy is aligned with the business strategy and these information are kept in a comprehensive knowledge base used to identify, prioritise, design and build the enterprise's information systems. ***Information Engineering*** consists of four phases, namely ***Information System (Strategy) Planning*** (***ISP***), ***Business Areas Analysis*** (***BAA***), ***Systems Design*** and ***Construction***. Descriptions of these phases and other Information Engineering terms are discussed in Chapter 6 and included in the Glossary.

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CHAPTER 2: SMALL BUSINESS AND INFORMATION TECHNOLOGY

2.0. INTRODUCTION

The practice of small business computing has already been in existence for more than two decades and there have been many recent studies concerning Information Technology (IT) in Small Business. With the proliferation of personal computers in the early eighties and availability of user-friendly software coupled with cheaper costs of hardware and software more and more small businesses are acquiring IT. In fact today, IT in a small business is a necessity, no longer a luxurious commodity exclusively for large businesses. However problems related to IT in small business are unique to the small businesses themselves. Many of the issues related to IT have been studied for large businesses but they are not necessarily applicable in the small business environment. Therefore separate studies concerning every aspect of IT are required if the role of IT in small business is to be understood.

In order to research IT in small business, first and foremost it is necessary to know what constitute a small business. This is done by examining the numerous definitions of small business across different parts of the world so that a common theme can be established as a basis for small business definition used in this study. After an understanding of what makes up a small business, it is also necessary to highlight the economic significance of small business and why studies into small business should be encouraged. The importance of small business particularly in relation to IT can be better appreciated by examining characteristics that are unique to the small firms. The chapter examines these characteristics and discusses some of the underlying issues faced by small firms in their use of IS and IT adoption. The remainder of the chapter reviews some of the related literature on IS usage and IT adoption in small business and the chapter ends by looking at current research into IT Sophistication in small business.

2.1. THE DEFINITIONS OF SMALL BUSINESS

The definition of a small business varies across countries and even across regions within some countries. This is because the importance of small business in terms of contributing to the social and economic development of the country or region has prompted governments as well as local councils to formulate specific policies and plans to aid small businesses. Various agencies and statutory bodies have been set up specifically to support the small business in terms of providing financial assistance, tax relief, management assistance, technical advisory, legal aid, research and development, grants and subsidies. Due to the specific interests of these support structures different criteria have been used by these agencies to define the small business entity in order to qualify for some kinds of assistance. This goes some way to explaining the lack of a universal definition of what makes up a small business.

The varying definitions could be demonstrated by examining what different countries across the globe define as small business.

2.1.1. Definition in the United Kingdom

Starting with the United Kingdom, an 'economic' definition of a small business which is widely used today is contained in a report by the Committee of Inquiry on Small Firms also known as the Bolton Report published in 1971 (HMSO, 1971). According to this report the definition of small firm is based on 3 essential characteristics. These are: (i) a small firm should have a relatively small share of its market; (ii) that it be managed by its owners or part-owners in a relatively 'personalised' way; and (iii) it is relatively independent in that it does not form part of a larger enterprise and that owner-managers have the freedom to make their own major decisions.

Despite these characteristics, the definition of small firm is not straightforward and depends largely on the type of industry or the specific type of assistance sought (DTI, 1995 p.11). For example different criteria are used for determining eligibility for the Small Firms Loan Guarantee Scheme or for the Small Firms Merit Award for Research and Technology (SMART). Cross (1983) for instance argued that a small chemical or cement firm in the manufacturing industry would be a large firm in the engineering or construction industry. The definition varies from being based mainly on employment or turnover (or both), to the size of the premises, and the size of the exports or profits. In the case of the road transport industry for instance, firms with 5 or less vehicles are considered small. To be eligible for government assistance on office development a small firm should occupy a premise of not more than 30,000 sq.

ft., and for VAT registration, the annual turnover of a small firm must not exceed £15,000 (Cross, 1983 p. 89).

Realising the importance of a single official definition the Department of Trade and Industry has recently adopted a simple definition used by Eurostat in the publication *Enterprises in Europe* which was based on firm size (Eurostat, 1992). Under this definition firms are grouped into four classifications according to firm size based on the number of employees. Table 2.1 below shows the classification groupings that are used to examine trends across industries and geographical areas (DTI, 1995).

Table 2.1. Classification of Firm Size

Classification	Number of employees
Micro	0 - 9
Small	10 - 99
Medium	100 - 499
Large	500 +

2.1.2. Definition in Other Countries

Table 2.2 shows the various definitions of small business adopted by different countries across the globe. In some countries the definition varies across different industries and regions, and according to employee size, turnover and/or capital. In other countries the definition is based specifically on employee size and/or turnover.

Table 2.2. Definitions of Small Business by Country

Country	Definition	Guideline	Sources
United Kingdom	Varies according to industry, assistantship and employee.	Less than 100 employees	DTI, 1995
United States	Varies across states and federal agencies.	Less than 20 employees $2.5 million turnover	US Congress, 1953 Nappi & Vora, 1980
Japan	Varies according to industry, capital and employee.	Manufacturing & Mining: Capital: less than ¥100 million Employees: less than 300 Wholesale: Capital: less than ¥30 million Employees: less than 99 Retail & Services: Capital: less than ¥10 million Employees: less than 50	Anthony, 1983 Dana, 1998
Australia	Varies according to industry and employee.	Less than 20 employees	Yamanaka, 1981 Atkins & Lowe, 1997
Sweden	Based on employee size.	Less than 200 employees	Lindmark, 1983
France	Based on employee size.	Less than 50 employees	Vickery, 1986
Germany	Based on employee and turnover.	Less than 50 employees Less than DM1 million	Kayser & Ibielski, 1986

Continue Table 2.2. Definitions of Small Business by Country

Country	Definition	Guideline	Sources
EC	Based on employee, turnover and state aids.	Less than 50 employees Less than ECU 7 million turnover Less than ECU 5 million balance sheet	DTI, 1997a
Indonesia	Based on employee and turnover.	Less than 20 employees Less than Rp0.5 million turnover	Soon, 1983
Malaysia	Based on employee and turnover.	Less than 150 employees Less than RM2.5 million turnover	SMIDEC, 1995
Singapore	Based on employee and assets.	Less than 100 employees Less than S$12 million assets	Thong & Yap, 1995
The Philippine	Based on employee and turnover.	Less than 100 employees Less than 1 million pesos	Soon, 1983
Thailand	Based on employee and turnover.	Less than 50 employees Less than 2 million bhats	Soon, 1983

Based on the definitions and guidelines from all these countries, it is interesting to note that a common theme appears in the definition of a small business. The firm size or specifically the number of employees seems to be an important criterion used though its quantity differs from country to country as presented in Table 2.2 above. For the purpose of this thesis and the research studies that have been carried out the small firm classification of Table 2.1 has been adopted. This means businesses classified as *micro* and *small* that employ less than 100 employees are included. Due to the nature of small business specifically related to the lack of formal structure and limited technical expertise, it would be justified to include only those firms with no formal IT structure and the absence of IT professional. This is in keeping with the specific interest the study is investigating, similar to other interests that various institutions have adopted in their definition of small business.

The varied definitions of small business suggest various measures are being taken by governments and the business community at large to help in the firms' long term survival. This is necessary as the small business sector plays a very important role in a country's social and economic development as demonstrated in the section that follows. This makes it the more important to encourage separate studies into small business as findings from such studies would addressed the specific issues concerning the small business. In turn these findings may have the potential to pervade across the wider small business community with significant impact upon the social and economic development of the country.

2.2. SIGNIFICANCE OF SMALL BUSINESS

The importance of small business to the national economy has been well recognised. In fact a strong and successful small business sector is vital for the nation's economy. Small businesses provide greater flexibility to the economy and they encourage the creation of new jobs. They have the capability to be more innovative, they complement the business of their larger counterparts from one of supplementary supplier in the upstream market to becoming a strategic partner in the downstream activities. Small businesses also encourage healthy competition both within the domestic market and internationally.

Two quotes from two government officials representing two differing countries may help summarise the universal recognition of the small business contribution. According to the Right Hon. Margaret Beckett MP, President of the Board of Trade, Department of Trade and Industry:

> "*Small firms create employment, promote competitiveness, innovate and create wealth right across society. Small firms can give a <u>big boost to our economy</u>.*" (DTI 1997b)

In an inaugural speech to mark the country's way forward to become a fully developed nation by the year 2020, the Prime Minister of Malaysia Mahathir Mohamad made the following statements:

> "*Small and Medium Scale industries have an important role to play in generating employment opportunities, in strengthening industrial linkages, in penetrating markets and generating export earnings. ...... The Government will devise appropriate assistance schemes and will seek to raise the level of management expertise, technological know-how and skills of the employees in this <u>very important and in many ways neglected sector of our economy</u>. ....*"
>
> (Mahathir Mohamad, 1991)

The above statements emphasise the importance of small business as agents of regional and national development. Through small businesses the nation's wealth can be equitably distributed as more individuals are involved in varied activities. This will contribute towards increasing the workforce population, the creation of new businesses, and help stabilise and expand the output of the economy even in time of recession (Blackburn and Jennings, 1996; Fuller, 1996).

In many countries small business accounts for more than 90% of the total number of businesses (Poon and Swatman, 1999). Small business also contributes more than half of all jobs, and produces more than 50% of the countries GDP (Joyce et al., 1996). Studies in many countries show the significant contribution small business makes to these countries. Table 2.3 shows some of the available statistics on the small business contribution taken from these studies.

Table 2.3. Small Business Contribution by Country

Countries	% of Total Business	% of Total Employment	% of GDP	Source
United Kingdom	99.6%	53%	44%	DTI (1996)
United States	99.5%	50%	40%	Robertson (1996)
Japan	99+%	80%	60%	Robertson (1996)
Germany	99+%	64%	50%	Robertson (1996)
Singapore	97%	N/A	N/A	Hashim et al. (1995)
Malaysia	70%	50%	N/A	Moha Asri A (1999)
Thailand	N/A	40%	N/A	Soon (1983)
Philippine	N/A	80%	N/A	Soon (1983)
Indonesia	N/A	82%	N/A	Soon (1983)

Table 2.3 above shows that 99% of businesses in the developed countries come from small business. In terms of employment small business in most countries above contributes more than 50% of all jobs. This is also true elsewhere in Europe where more than 99% of all establishments in the European Union (EU) are categorised as small and medium enterprises (SMEs). Together small firms in the EU contribute more than 70% of the total employment (Robertson, 1996 p. 60).

The preceding discussion demonstrates the important and significant contribution of small business to any country's economic prosperity irrespective of the status of the country. Any efforts at assisting the small business community are much encouraged since a larger proportion of the business population would benefit from these efforts, which in return would contribute to the nation's socio-economic development. Various schemes and incentives have been specially created to assist small businesses under the auspices of government ministries and departments to encourage public and private institutions especially large businesses to participate in promoting small business development. The establishment of Business Links by the Department of Trade and Industry in the UK is an example of this where a formal network between key local enterprise support organisations is established (DTI, 1994). Partnerships between the Training and Enterprise Councils (TECs), Chambers of Commerce, Enterprise Agencies, Local Authorities together with other private organisations such as banks, legal and accountancy practices were formed aimed at providing a One-Stop shops for small business support services.

It has long been recognised that small businesses are more susceptible to unfavourable conditions that would put them at greater risk of business failure compared to larger businesses. According to Yamanaka (1981, p. 104-105) these conditions which include financial ability, management resources, capital accumulation, labour conditions, marketing power, and contracting power are on the one hand favourable to large businesses but on the other hand will place small businesses at a disadvantage and unfair competition. In reality these conditions are indications of actual problems faced by many small firm entrepreneurs. Among the many problems cited include financing, lack of capital, taxes, sales and marketing, export, quality and cost of labour, technological know-how, government red tape, competition from large firms, sub-contracting, availability of suitable premises, and managerial incompetence. Therefore the many schemes and incentives created (over 300 in the case of France alone - Vickery, 1986) are aimed at addressing these problems and moderating the unfavourable conditions but most importantly to ensure the survival and growth of the small firm.

An understanding of the characteristics of small business is essential in order to appreciate the problems inherent in small firms and how these firms manage to cope with the unfavourable conditions amid the presence of numerous aids and assistance. These characteristics are also important to differentiate the specificity of small business particularly with respect to Information Systems and the adoption of Information Technology.

2.3. CHARACTERISTICS OF SMALL BUSINESS

In discussing the characteristics of small business one may be tempted to think that a small firm is a scaled down version of a large firm. It is probably true if a firm is thought of as an entity that needs to be registered with proper book-keeping and account maintenance, has people in it, and whose business need to be managed. Furthermore, all businesses require proper allocation of resources, whose functions are primarily to utilise the resources to support the creation and selling of the products and/or services, to maintain and develop the products and/or services in order to ensure continuous and sustainable growth. Above all the idea of going into business is to be profitable for long-term survival. However, studies have shown that small firms possess unique characteristics different from large firms, have different problems not encountered by large firms and require different treatment and approaches (Raymond, 1990b).

It goes without saying that an obvious characteristic of a small business is its size. It is the size of the business that differentiates between 'small' and 'large' businesses. As has been discussed previously from the definitions of small business, firm size can be measured in several ways. One commonly used measurement is the number of people employed. Other indicators of size include sales turnover, capital and fixed assets of the firm. It is on the basis of size that other essential characteristics of small business emerge and this could be explained from a historical perspective.

According to Yamanaka (1981, p. 7) historically it was the introduction of the new big capitalist enterprises known today as the large-scale firms and multi-nationals that brought about the conscious recognition of small business. This consciousness as belonging to the old sector of business which necessitates this differentiation in character between 'small' and 'large'. In the process of industrialisation, whilst these large-scale firms are being perfected and adapted in the newly created capitalist economy, the old sector known today as small businesses is left behind and seen to inherit 'deficiencies' in its characters vis-à-vis the large businesses. Hence the concept of small business was born to address these 'deficiencies' which when looked from the positive perspective are characteristics that have evolved and survived to the present time.

It is these characteristics that will be examined in this section particularly in relation to Information Technology (IT); and firm size being a distinct characteristic of small business has been associated with the success of Management Information System (MIS) implementation in early studies of IT in small business (Ein-Dor and Segev, 1978; DeLone, 1981).

The 'smallness' of the business as reflected in its size has prompted others to characterise small businesses as 'an extension of the entrepreneur's own personality' (DeVries, 1977; Blili and Raymond, 1993). This means that small businesses tend to rely on the entrepreneur or owner-manager on every aspect of the business. It is the owner-manager who creates the business and naturally he/she tends to dominate the functioning of the business (Palvia and Palvia, 1999). In fact Lees (1987) found that small businesses place heavy reliance on the owner-manager's personal experience which could encourage dictatorial decision-making (Lees and Lees, 1987). This is supported by Doukidis et al. (1996) who suggest that top management of small firms tends to be autocratic with directives coming from a single person.

This autocratic style of leadership leads to other characteristics of small business. These are an informal structure and centralised decision-making. Lack of a formal organisation structure results in minimal or no differentiation among operating units, hence facilitating direction from the top. With centralised structure, delegation of responsibilities will become rare resulting in reactive, short-term and impulsive decisions (Blili and Raymond, 1993 and Doukidis et al., 1996). Decisions are also seen as ad-hoc, one-shot occurrences and usually unstructured or semi-structured (Gupta and Harris, 1989). But according to Blili and Raymond (1993) this would encourage shorter time frame to make decisions and quick implementation of the decisions. However, the short time horizons and short-range management perspective put much emphasis on the daily operation of the business rather than strategic and long-term business planning (Lees, 1987). Because of this, according to Doukidis et al. (1996), planning is generally considered not important and too time consuming. This is also consistent with Proudlock et al. (1998) who found that planning remains non-existence in the majority of small firms with fewer employee size though there is a growing trend among small information-intensive firms to employ formal business and IT planning.

With the lack of planning, addressing environmental change will be problematic for small business because interacting with the environmental forces, both within and external to the firm would require proper strategy and careful planning. In fact according to Blili and Raymond (1993), environmental forces such as finance, information, competition, etc. are threats to small businesses that may affect their livelihood. They contend that small businesses have a higher mortality rate and their chances of failure are higher than large businesses. Small businesses are particularly affected by financial uncertainty which poses the greatest problem for small firms and has been the subject of most debates in small businesses (Storey, 1983 p. 5; Blackburn and Jennings, 1996 p.2).

Another environmental specificity is Information Technology, where generally small businesses lack the knowledge and experience in the adoption of IT resulting in their over reliance on vendors and other technology suppliers (Lees, 1987). Raymond (1990b) contends that small businesses are characterised by their lack of managerial expertise to manage their own information resources. This is aggravated by their lack of formal Information Systems organisation or department (Palvia et al., 1994; Raymond, 1990b) that reflects their informal structure and no IT professional to handle IS development and to provide technical support (Gupta and Harris, 1989; Lees and Lees, 1987). This has also contributed to their lack of formalised systems (Pollard and Hayne, 1998), and formal selection processes that make small businesses susceptible to problems with new hardware and/or software, and poor user attitude towards IT (Lees and Lees, 1987).

Another technological characteristic of small business is their low level of sophistication in application development having an application portfolio largely transactional in nature and IS very much under-utilised (Raymond, 1990b). Information is often not shared across the firm and tends to be at the disposal of the owner-manager. IT is often under-utilised, informal information systems exist with poor integration and ambiguous job responsibilities (Blili and Raymond, 1993; Doukidis et al., 1996). However positive management attitude has long been seen as a success factor for IS usage and IT adoption and this is encouraged by the general perception of many small businesses that IT is a "modern management requirement" (Malone, 1985).

2.4. INFORMATION SYSTEMS USAGE AND IT ADOPTION IN SMALL BUSINESS

Today, an increasing number of small businesses are adopting Information Technology (IT) in their effort to develop a competitive advantage and maintain their position in the marketplace. According to Lees and Lees (1987), the reasons for small business owners implementing information systems (IS) are to improve operational procedures, to produce information at a lower cost, to make available new management tools for decision making, to facilitate billing and invoicing, to facilitate business growth through computer control, to facilitate inventory control, and simply to be innovative. The benefits derived include better record keeping, timely, accurate, and expanded information, improved customer service, increased productivity, and enhanced management control and decision-making. Magal and Lewis (1995) suggest that IT adoption can increase efficiency of operations through more efficient processes, better record keeping, and improved data collection; increase the effectiveness of decision-making through better information; and increase the firm's competitiveness through increased sales and better customer service.

The significance of small businesses and their specificity as reflected by their unique characteristics have prompted many researchers to study IS success and IT adoption in small businesses (Lees, 1987; Montazemi, 1987,1988; Raymond, 1985,1990b; DeLone, 1988; Kagan et al., 1990; Yap et al., 1992; Lai, 1994; Magal and Lewis, 1995; Hashim et al., 1995; Palvia, 1996; Igbaria et al., 1997; Palvia and Palvia, 1999). Lees (1987) for instance studied the factors that determine IS satisfaction and usage in small businesses. The author found greater adoption of IS in firms with formal development methodologies, involvement of end-users in IS projects, with IT expertise, with good vendor relationships, with experience in using computers, and top management with IT experience, 'larger' small businesses, and firms which operate in a competitive environment.

Montazemi (1987) studied the adoption and assessment of IT in the small business environment. Investigation of the characteristics of end-users, IT personnel, and strategies and tools for IS development are done. The results of this study indicate small businesses generally have end-users with low level of computer literacy and received elementary formal education. In addition, small businesses lack qualified IT personnel, no specific policy and planning on the acquisition of hardware and software, lack of formal IS methodology, lack of end-user participation and minimal technology diffusion throughout the firm. In another study (Montazemi, 1988) the author studied the factors affecting end-user satisfaction with IS in the small business environment. Results of the study are consistent with the previous study and show that among the factors affecting end-user satisfaction are the presence of IT personnel, end-user computer literacy and involvement in IS development, number of interactive on-line applications, and the degree of decentralisation of the organisation. Computer experience however was not found to be directly related to end-user satisfaction.

In a study to investigate the factors affecting the successful use of IS in small businesses, DeLone (1988) found that top management familiarity and involvement with computers is a key factor that determines IS success in small businesses. Other success factors include in-house or on-site computer use, planning for application portfolios, and the presence of basic computer controls. Other factors studied but found to be inconclusive include computer experience, source of technical support, employee acceptance of IS, and formal computer training.

Using Ein-Dor and Segev's conceptual framework as the theoretical foundation, Raymond (1990b) found that organisational size, maturity, resources, time frame and IS sophistication are important for IS success. The author proposed that organisational structure such as degree of centralisation and integration are potential contributors for IS success.

Kagan et al. (1990) studied IS usage within small businesses across industrial sectors and found different sectors of the industry uses IS for different purposes. The authors also studied software (computing) sophistication within different industrial sectors and found the wholesaling sector to be the most sophisticated whilst the manufacturing sector has the largest proportion of firms that developed their own applications. The authors suggest that the manufacturing sector has unique software needs that are not currently being addressed by current software products. This is also supported by Culpan (1995) who found that employees in the manufacturing industry tend to make less use of computers compared to the service industry in terms of meeting their job requirements, convenience of use and solutions to problems. The findings also suggest manufacturing firms use computers for decision making and controlling more, whilst service firms use computers for data processing. Moreover, according to Dahalin and Golder (1998b) third party sources, vendors and consultants would tend to shy away from such small and unique business needs with limited potential for mass production of software in the interest of their own business strategy.

Yap et al. (1992) identified six out of eight key factors that are significant for IS success in small businesses. These are consultant effectiveness, vendor support, IS experience, financial resources, top management support, and user participation. The number of administrative applications and presence of IT personnel were not found to be related to IS success. In another study the same authors found small businesses with consultants tend to have higher IS usage, better production of computer reports, and maintain up-to-date information but IS projects tend to be delayed and costs of computerisation underestimated (Soh et al., 1992).

Using similar factors described by Yap et al. (1992) for IS success in small businesses, Peng et al. (1992) proposed guidelines for successful computerisation for small businesses. These are developing awareness in all aspects of computerisation, showing strong commitment to computerisation, performing feasibility studies, selecting the most appropriate computer systems solutions and evaluating the implemented computer system.

In a survey of rural small business computer use Lai (1994) found several factors that affect success of computer use. The factors include the firm's computer experience, rank of the IS organisation function, and age of the business. The study also reveals computer use in small businesses is limited to supporting operational activities as opposed to using computers as tools to aid decision-making.

In another study on IT success in small businesses, Magal and Lewis (1995) found that IT awareness is a critical factor determining IT success. Another behavioral factor, attitude towards IT is indirectly related to IT success via awareness of IT. The authors also stresses the importance of being aware of the "more sophisticated applications" as this has not been adequately addressed in small businesses.

Despite the number of studies on IT adoption and IS success in small businesses, there have been arguments recently that studies on IT and the use of IT in very small businesses are not adequately addressed and are still in their infancy (Palvia et al., 1994; Palvia, 1996; Palvia and Palvia, 1999). These arguments appear well founded as there has been consistent evidence that the firm size is a determining factor for both IT adoption and IS success in small businesses. This implies that IT requirements and other IS issues in very small businesses are different from 'large' small businesses. Hence separate studies for these groups of firms are justified especially in light of their contribution to the nation's economy. It should again be stressed that in the UK for instance 94.5% of all businesses are categorised as 'micro' or very small businesses, that is firms employing less than 10 people (DTI, 1996). The distinguishing characteristics of this group of firms are the absence of a formal IS structure and no IT expertise to support the adoption of IT.

In light of the above discussion, Palvia et al. (1994) found that the firm size, age of the business, educational background of owner-managers, their computer knowledge, and profitability of the business are important factors for computer use in very small businesses. Palvia (1996) further developed a comprehensive model for measuring IT satisfaction in very small businesses and came up with a construct consisting of end-user computing satisfaction characteristics, characteristics associated with traditional data processing environment, and characteristics specific to small business environment. Palvia and Palvia (1999) tested this model and found training and education, software maintenance, documentation, and vendor support to be important issues of concern among small business users in the context of IT satisfaction.

2.5. INFORMATION TECHNOLOGY SOPHISTICATION

Whilst much progress has been made in the areas of IT adoption and IS success in small business, there have been few studies on IT or IS sophistication. Though the factors contributing to the adoption of IT and IS success may also influence the level of IT sophistication of small businesses, a study of IT sophistication in itself would lead to greater insight into "the nature, complexity and interdependence of IS usage (IT adoption) and management in an organisation" (Raymond and Paré, 1992). The authors contend that there is an imbalance between the levels of IT sophistication in terms of IT adoption and IS management in small firms, where the former tends to be on the increase whilst the latter has a low level of sophistication.

Cragg and Zinatelli (1995) concur that IT in small businesses has become more sophisticated. The authors found that IS usage by small firms in their longitudinal field study has evolved with more sophisticated hardware and software, and an increase in end-user computing sophistication. However the level of end-user sophistication is still low with most users classified as non-programming end-users that used menu-driven applications. On the other hand the study also revealed an increase in the applications portfolio with increases in new fully-fledged accounting systems, payroll and computer-aided design (CAD) packages.

In a related study, Cragg and King (1993) examined factors that influence the levels of computing sophistication in small businesses. The authors examined motivators and inhibitors of growth in the context of the evolution of small firm computing. The strongest motivating factor for increased computing (IT) sophistication in small businesses was found to be top management's enthusiasm (attitude) towards computing. Other factors include cheaper hardware and number of application packages. Inhibiting factors include lack of IS knowledge, time constraint, lack of support, and limited resources. It is interesting to note that most of these factors are similar factors found in studies of IT adoption and IS success described in the previous section.

Kagan et al. (1990) adopted a different approach to studying IT sophistication in small business by developing an instrument to measure the software (computing) sophistication level. Their intention is to determine the relationships between software sophistication and the different types of business sectors, firm sizes, telecommunication capabilities, and software satisfaction. Since the level of application sophistication is very subjective as argued by the authors, an index representing opinions from computer professionals and academics was used to rate each software product to indicate the level of sophistication implicit in its use. The index is accumulated for each product and mean scores are computed giving the weighted average scores for all the products.

Table 2.4 shows the results of the mean scores from the computer professional and academics opinions survey and the sophistication construct developed by Kagan et al. (1990). The results show that Word Processing, being the most widely used software, was also judged to be the least sophisticated in terms of application usage. Spreadsheet, which is the other common software used, was also perceived to have lower level of application sophistication. On the other hand, database applications along with decision support applications and telecommunication and networking applications are rated as highly sophisticated.

The Sophisticated Score Construction shown in Table 2.4 is used to compute the software sophistication level of the firm. The score represents the total mean scores of all corresponding software products used by the firm. Since the original opinion were expressed on an interval scale ranging from 1 to 10, where 1 is rated as the least sophisticated and 10 rated as the most sophisticated, the total mean scores (ie. raw scores) are transformed so that their values fall within the 1 to 10 range. The idea is to obtain a sophistication index similar to the original scale so that the same interpretation for the level of sophistication can be applied. Kagan et al. (1990) named this transformed score the Software Sophistication Index (SSI). In this way Kagan et al. (1990) developed an objective measure of sophistication based on the opinions of experts in the IS field.

Table 2.4 includes an example of how a firm's SSI is computed.

Table 2.4. Computer Professional and Academics Opinions Applications Mean Scores and Sophistication Index Construction

Application	Mean Score
Word Processing	1.65
Payroll	3.26
Spreadsheet	4.03
Ordering	4.03
Pricing (invoice and billing)	4.08
Employee/Personnel	4.19
Inventory Control	4.64
Branch Inventories/Fixed Asset	4.75
Data Applications	5.16
Telecommunications	5.74
Database	6.13
Decision Models	7.87

Continue Table 2.4

Sophisticated Score Construction

Score = $\sum_i$Application$_i$ * Mean Score$_i$

for i = 1 to number of applications
where each application is a binary variable (1 for Yes, 0 for No)

Software Sophistication Index
The score is transformed such that its value is between 1 and 10 which is consistent with the system's professional's survey. The transformation formula is:

$$SSI_j = (score_j + a) / b$$

where SSI_j is the software index of firm j after transformation. a and b are chosen such that $1 < SSI_j < 10$, and determined by solving the following equations

$$10 = (max + a) / b$$
$$1 = (min + a) / b$$

where max and min are the maximum and minimum sophistication.

Example, if $Firm_j$ has Word Processing, Spreadsheet and Database, SSI_j is computed as follows:

$Score_j$ = 1.65 (Word Processing) + 3.26 (Payroll) + 4.03 (Spreadsheet) + 4.03 (Ordering) + 4.08 (Pricing) + 4.19 (Employee/Personnel) + 4.64 (Inventory Control) + 4.75 (Branch Inventories) + 5.16 (Data Applications) + 5.74 (Telecommunication) + 6.13 (Database) + 7.87 (Decision Models)
= 1.65(1) + 3.26(0) + 4.03(1) + 4.03(0) + 4.08(0) + 4.19(0) + 4.64(0) + 4.75(0) + 5.16(0) + 5.74(0) + 6.13(1) + 7.87(0)
= 1.65 + 4.03 + 6.13
= 11.81

Assuming that min is 1.65 and max is 55.54, therefore a = 4.34 and b = 5.99
Substitute into the SSI formula above,

SSI_j = (11.81 + 4.34) / 5.99
= 2.70

Firm j therefore has a Software Sophistication Index of 2.70 in the scale 1 to 10, where 1 is the least sophisticated and 10 the most sophisticated

Source: Kagan, Lau and Nusgart (1990)

Using the Software Sophistication Index (SSI) scores Kagan et al. (1990) found differences in the levels of computing sophistication across industries, with the wholesaling sector being the most sophisticated in terms of hardware and with retailing being the most sophisticated in terms of software. The study also reveals that the manufacturing sector has more firms that develop their own applications, a sign of an increasing level of end-user computing sophistication in small manufacturing firms.

2.6. SUMMARY OF THE RELATED STUDIES

This chapter has examined the studies on small business in relation to the adoption of IT. On the characteristics of small business there has been a consensus that no universal definition of small business is required. Countries and agencies looking after the well being of small firms adopted their own criteria of what constitute a small business in order to serve their own interests. This could well be to encourage socio-economic growth in certain sectors of the industry by providing grants and subsidies to certain types of businesses with certain characteristics and nature. As a result numerous definitions of small business exist but most of these definitions were based on a single factor namely, firm's size. Two measures of firm's size have been used, that is the number of employees and to a lesser extent the annual sales turnover. It has been argued that due to the sensitive nature of performance-related data, firms are more reluctant to disclose their true sales figures compared to the number of employees they have. Hence firm's size is usually measured by the number of employees and most definitions used 100 as the limit to classify a small business. To a lesser extent 50 employees has also been used in some countries to denote a small firm. For the purpose of this study the definition of small firms is adopted from the UK's Department of Trade and Industry which classifies a small firm as having less than 100 employees.

The specificity of small business in relation to other large businesses in terms of IT has encouraged numerous studies be done in this area. These studies have found significant differences of IT adoption and IS usage in small firms and recognised the need to have separate studies of IT within the specificity of small business. This specificity can be attributed to the characteristics of small business, which have been discussed in this chapter and summarised in Table 2.5 below. The significant contribution of small business to a country's social and economic development has also made studies on IT adoption and IS usage in small firms the more important and justifiable.

Table 2.5. Summary of Small Business Characteristics

	Characteristics	Article
Organisational characteristics	Size - number of employees and sales Limited resources - financial and human Owner-manager dependent and dominion Autocratic leadership - dictatorial and centralised decision-making Unstructured or semi-structured decisions Reactive, short-term and impulsive decisions Ad-hoc and one shot occurrences of decisions Quick implementation of decisions Informal organisation structure Lacked delegation of responsibilities Emphasis on daily operation No strategic and long-term business plan	Ein-Dor & Segev(1978), DeLone(1981); Blackburn & Jennings (1996); Lees (1987), Palvia & Palvia (1999); Lees & Lees (1987); Gupta & Harris (1989), Doukidis et al. (1996), Blili & Raymond (1993); Blili & Raymond (1993); Palvia,Means & Jackson (1994), Raymond (1990b); Lees (1987), Lai (1994); Doukidis et al. (1996)
IT characteristics	Lack of IT expertise, knowledge and experience Dependent on vendors and suppliers for IT solutions Lack of managerial expertise to manage information resources No formal IS organisation structure/department No IT professional to handle development and technical support No formal selection process for hardware and software Negative user attitude towards IT Low level of application development Largely transaction processing based applications IS under-utilised Lack of formal IS with poor integration Lack of formal IS methodology Lack of end-user involvement in IS projects Low level of computer literacy	Raymond (1990b), Gupta & Harris (1989), Lees & Lees (1987), Montazemi (1987); Raymond (1990b) Palvia,Means & Jackson (1994); Gupta & Harris (1989), Lees & Lees (1987); Pollard & Hayne (1998); Lees & Lees (1987); Magal & Lewis (1995); Raymond (1990b); Raymond (1990b); Raymond (1990b); Blili & Raymond (1993), Montazemi (1987,1988), Lees (1987)

Most of the studies on IT in small business have been in the areas of IT adoption, IS success, IS usage and IS satisfaction. Table 2.6 below summarises the related studies in these areas along with the associated factors discussed in this chapter. Main factors can be classified into Organisational, Management, Technology and Behavioural factors. Organisational factors identified include firm size, maturity (age) of business, location of firm, industry sector, profitability, degree of centralisation/ decentralisation, vendor support, end-user involvement and participation, training and education. Management factors identified include top management support and involvement, CEO knowledge and experience, IT policy, strategy and planning. Technology adoption factors include development methodology, hardware and software selection, computer control, application portfolio, IS sophistication, software sophistication, IS organisation, and IT/IS experience. Attitude and awareness of IT made up the Behavioural factors.

Table 2.6. Summary of Related Studies on IT Adoption and IS Success Factors in Small Business.

Article	Areas/Factors
Lees (1987) DeLone (1988) Raymond (1990b) Kagan et al. (1990) Yap et al. (1992) Lai (1994) Magal & Lewis (1995)	IS Success, IS Satisfaction and IS Usage in Small Business. ▪ Formal development methodology, end-user involvement and participation, IT expertise, IT experience, firm size, application portfolios, organisational centralisation/decentralisation, top management support and involvement, in-house adoption, organisation maturity, IS sophistication, software (computing) sophistication, industry, vendor and consultant support, location, IT awareness and attitude.
Montazemi (1987) Palvia et al. (1994) Palvia & Palvia (1999)	IT Adoption and Assessment in Small Business ▪ Computer literacy, education and training, IT expertise, hardware & software acquisition, end-user participation, firm size, organisation and IS maturity, CEO qualification, IS strategy, IS tool, profitability of business, software maintenance, vendor support.

Fewer studies have been done on IT Sophistication in small business. The articles and some of the factors examined in these studies are summarised in Table 2.7 below. Most of these factors are similar to the IT adoption and IS success studies. An objective measure of Software Sophistication developed by Kagan et al. (1990) will be used as a basis for measuring IT and EUC sophistication in this study. Taken together these measurements and factors together with those summarised in Table 2.5 and Table 2.6 formed the basis for the study of End-User Computing in small business discussed in the next chapter. Interestingly, one of the factors identified in one of the IT Sophistication study listed in Table 2.7 below include End-User Computing Sophistication itself.

Table 2.7. Summary of Related Study on IT Sophistication

Article	Areas/Factors
Raymond & Paré (1992)	IT Sophistication ▪ IT adoption ▪ IS management
Cragg & Zinatelli (1995)	IS Evolution in small firms ▪ Hardware & software sophistication ▪ End-User Computing Sophistication ▪ End-User Sophistication ▪ Application portfolio
Cragg & King (1993)	Computing Sophistication in Small Business ▪ Top management attitude ▪ Hardware costs ▪ Number of application packages ▪ IS knowledge ▪ IT support ▪ Resources
Kagan, Lau & Nusgart (1990)	Software (Computing) Sophistication in Small Business ▪ Application sophistication ▪ Business sector/industry ▪ Firm size ▪ Telecommunication capabilities

CHAPTER 3: END-USER COMPUTING IN SMALL BUSINESS

3.0. INTRODUCTION

Although the use of information technology and information systems can help improve the business prospects of small businesses, computerisation should nevertheless be approached with caution. The nature of small businesses, with limited financial and human resources and lack of technical expertise has placed them in a more risky situation and liable to higher failure rates than their larger counterparts. However, as has been discussed previously these threats can be transformed to opportunities when there is evidence of CEO knowledge and involvement in IS/IT adoption (DeLone, 1988), IS training and experience (Raymond & Bergeron, 1992), user participation and computer literacy (Montazemi, 1988), consultant effectiveness and vendor support (Yap et al. 1992), and the presence of End User Computing (Raymond 1985; 1987; 1990a). It is this last important issue that will be dealt with in this section as it is directly related to the area covered by the thesis. However, the rest of the issues above will also be examined in relation to End-User Computing sophistication within the context of the small business.

This chapter begins by looking at the various definitions of End-User Computing and proceeds to discuss the concept of End-User Computing with the aim to provide a general understanding of the subject and to show its importance as a researchable area of study. Generally regarded as a phenomenon rather than a technology the study of End-User Computing will not be complete without discussing its associated benefits and risks particularly within the small business context. The chapter examines the various models of End-User Computing revealing the underlying theoretical constructs and concludes by positing an initial model of End-User Computing Sophistication in small business.

3.1. DEFINITIONS OF END-USER COMPUTING

The term *End-User Computing* (EUC) in its broad sense can be defined as the tasks of using computers and IT resources to retrieve data and programs by managers, professionals and other knowledge workers (ie. non-IT professionals) in order to help facilitate their work. After almost two decades of research there is no standard definition of EUC and many studies have provided various definitions depending on the scope and focus of study. This is supported by Nord and Nord (1994) who observed that EUC is defined in a number of ways with no widely accepted definition. As a result different terms have emerged with similar connotations among them, including User-Developed Applications, End-User Development, Business User Development, and EUC Sophistication.

In order to show the numerous definitions of EUC and to gain better understanding of the meaning of the term, a number of definitions have been taken from several studies based on a review of the literature. Perhaps the earliest definition came from a status report by the CODASYL End-User Facilities Committee published in 1979 that defined EUC based on three categories of end-user (see Doll and Torkzadeh, 1988; Rockart and Flannery, 1983). These are indirect, intermediate and direct end-users. Indirect end-users refer to that group of end-users who use computers through other people. This situation usually occurred in the traditional DP environment where access to the mainframe computers and terminals are limited to those 'authorised computer personnel' only. Intermediate end-users are those who receive reports they themselves requested by specifying their information needs. Again, this usually occurred in the traditional MIS or Data Centre setup where reports and other ad-hoc queries were generated and passed to user departments. The third group of end-users, the direct end-users are more relevant to today's EUC environment where these are those who interact directly with the computers and actually using them within their working environment.

In describing EUC Rockart and Flannery (1983) provide similar categorisation based on end-users in terms of *who* are they, *where* are they located, and *what* they do. Their study reveals six distinct categories or typology in the order of increased sophistication of interaction with the computer. The lowest category, *Non-programming* end-users are those who interact with the computer through limited menu-driven interfaces to access data. Next, *Command level* end-users are those who access and manipulate data on their own through writing of simple queries, formulae, and using report generators to create simple reports for their own purpose. The third category is *end-user programmers* who use procedural languages and other third generation languages to develop their own applications for their own use as well as by other users. *Functional Support* personnel is the next category of end-users who are sophisticated programmers developing applications for other end-users within their particular business functions. The fifth category is *EUC Support* personnel who provide EUC support for the whole organisation and are usually located in Information Centres and/or the MIS departments. The final category is the *DP programmers* or IT professionals as it is commonly known today who develop the more complex and sophisticated organisational information systems.

Within small businesses however the end-user typology may no longer be relevant. This is particularly true in small firms with no formal IS structure and no IT expertise, and with the advent of PCs and fourth generation languages and other application generators the traditional Rockart and Flannery's end-user typology may need to be modified as suggested by Dahalin and Golder (1998b). The authors suggest a simpler typology consisting of three levels, namely "Simple" end-users, Command level end-users, and End-User Developers. The first two levels are similar to the corresponding Rockart and Flannery's first two categories. "Simple" end-users are those who use computers to access data through a limited menu-driven interface while Command level end-users are able to interact with the system on their own and know the systems' elementary functions to access and manipulate data. End-user Developers are those sophisticated end-users who are capable of developing their own applications independently and are also able to use the system's advanced features to create procedures and/or documents as application modules. This level of end-users would require sound business knowledge coupled with good development methodology and tools to become effective end-user developers.

Other definitions of EUC can be seen as variations along these three levels but the majority is more inclined towards the end-user developer spectrum. Some studies refer to those end-users using computers (McNurlin and Sprague, 1989; Igbaria, 1990; Igbaria and Zviran, 1991; Zinatelli et al., 1996). Whilst many studies on the other hand refer to those end-users actually developing their own applications (Floyd et al., 1995; Amoroso and Cheney, 1992; Aggarwal, 1994; Brancheau and Brown, 1993; Lawrence et al., 1997; Doll and Torkzadeh, 1990). McNurlin and Sprague (1989) for instance defined EUC as "the direct, hands-on use of computers by end-users". Igbaria (1990) defined EUC to include "anyone who uses microcomputers or computers" and together with Zviran (1991) described EUC as an "information processing activity performed by end-users" using computers to access data and programs. Zinatelli et al. (1996) confined their definition to the *optional* use of computers to assist the end-users' work and exclude end-users whose computer use is mandatory.

Studies of EUC that include end-user development in their definitions include Floyd et al. (1995) who defined EUC as the adoption and use of IT by personnel outside the IS department to develop application software. Amoroso and Cheney (1992) defined EUC as the dependence of end-users on IT to develop specific applications for their own use, within their department and/or organisation-wide. Aggarwal's (1994) definition of EUC is more restrictive as he confined EUC to "systems developed by end-users to support their decision making" and excludes other transactional and operational activities. However the author included support from IT professionals as necessary in the development process.

In an early comprehensive review of EUC literature, Brancheau and Brown (1993) defined EUC as "*the adoption and use of IT by personnel outside the IS department to DEVELOP software applications in support of organisational tasks*". The authors however exclude clerical office automation activities such as word processing, desk top publishing, and electronic communications in their definition, in addition to those applications developed by the IT professionals. However, to emphasise the direct involvement of end-users in business application development, Lawrence et al. (1997) suggest the term Business User Development be used as opposed to the general EUC definition. A much simpler definition of EUC is provided by Doll and Torkzadeh (1990) who include those end-users directly interacting with the applications they developed.

3.2. THE CONCEPT OF END-USER COMPUTING

With EUC the line separating the end-user and the professional developer is ever changing and is being redefined. In organisations with formal IT functions and EUC presence the roles of the professional developers are ever more significant and highly regarded. These IT specialists can be depended upon to develop the more complex and highly sophisticated information systems leaving the much simpler and straightforward applications to the knowledge workers who are today's end-users.

These end-users are becoming knowledgeable in IT and they can no longer be regarded as passive participants in IS development projects. The challenge is to provide a suitable platform for end-user application development and in recognition of this challenge, organisations have begun to allow end-users to develop their own applications independently or with minimum support from the IS developer. The emergence of end-user support groups and Information Centres for technical assistance is evidence of this development. However this is only part of the solution to the issue on end-user application development. Understanding the concept of EUC as supported by other related studies may provide insight into the significance of end-user application development particularly within the specificity of small businesses.

The development of applications by end-users has continued to receive much attention from both the IS academics and industry ever since the idea of EUC begun in the early 1980s. The concept of End-User Application Development therefore takes its origin from EUC and the concept of EUC is a manifestation from traditional IS development where the IS function can no longer cope with the increased demands for computerisation by user departments. Together with the proliferation of inexpensive microcomputers and user-friendly software, coupled with the increasing awareness of the benefits of IT adoption to reduce costs, improve service and sustain competitiveness, the trend in EUC will continue to grow. This growth together with the demands for computerised applications will continue to increase as reported in various studies.

As reported by Igbaria and Zviran (1991, 1996), the rapid growth of EUC is the result of the abundance of powerful and faster, easy to use yet cheaper microcomputers in the marketplace. The continued growth of EUC is also attributed to considerable backlog of user requests for new computer applications (Cale, 1994; Floyd et al., 1995) as well as with the development of user-friendly software and tools (Rivard and Huff, 1988; Chan and Storey, 1996). Aggarwal (1994) contends that EUC has received much interest by academics and practitioners as well as end-users at all managerial levels and that these end-users are becoming more sophisticated and require a more sophisticated IT support. Meanwhile Szajna (1994) suggests that research in the areas of EUC along with data management and software development should continue despite the fact that these were issues identified by IS researchers as critical to IS practitioners as far back as in the early 1980s.

EUC has been one of the key issues of concern in IS management since the 1980s (Dickson et al. 1984; Wood 1988; Brancheau and Wetherbe 1987; Niederman et al. 1991), and continues to be of concern throughout the 1990s (Teng and Galletta 1990; McLean et al. 1993; Brancheau et al. 1996; Palvia et al. 1996). In the first such study of IS key issues undertaken by Dickson et al. in 1983, EUC was ranked second. In the mid to the late eighties, Brancheau and Wetherbe (1987) and later Wood (1988) conducted similar studies and both studies found EUC has grown in proportion and ranked among the top ten IS key issues. In the early 1990s though few studies such as McLean et al. (1993) and Brancheau et al. (1996) have shown some drop in the EUC ranking (ie. 18^{th} and 16^{th} positions in 1990 and 1994, respectively), other studies still maintain EUC ranking within the top ten IS key issues. Palvia et al. (1996) conducted a trend analysis over a four-year period from 1989 to 1992 and found EUC to be within the top ten IS key issues.

However it was a recent study by Pollard and Hayne (1998) that is most remarkable and surprising. The authors not only reported that EUC was the third most critical IS issue, but their research was undertaken among small businesses. This shows that whilst it may be true to say that the criticality of EUC as an IS issue has diminished, this may only be true for the large businesses where previous studies have been based on. As far as small businesses are concerned EUC is still one of the most critical IS issues as shown in this later study. This also supports the idea that warrants separate studies on EUC in particular and IS in general within the specificity of small businesses.

However, as EUC is now approaching its second decade studies on EUC in small businesses are just beginning to surface. This is evidenced from a study by Brancheau and Brown (1993) in which out of almost 100 articles examined across a ten-year period, only two articles are associated with EUC in small business with both belonging to Professor Louis Raymond (1987, 1990a). This clearly indicates the relatively little research in this particular area where more studies need to be undertaken to extend and accumulate the body of knowledge on EUC in small businesses.

Earlier studies of EUC in small businesses could be traced back to the mid 1980s when Raymond (1985) found that small firms are capable of developing their own IS applications. In a study of the presence of EUC in small business, the same author reported that the firm's size and levels of decentralisation influence the presence of EUC (Raymond 1987). Later the author suggests EUC in small business should be an extension of organisational computing and studies on organisational factors contributing to EUC success should be encouraged (Raymond 1987, 1990a). In another study the author found that since the amount of computer experience of small business managers lead to stronger participation in systems development, computer training can be an alternative to encourage managers to develop applications in the absence of computer experience (Raymond 1988).

In the mean time, Montazemi (1987, 1988) found that end users in small firms experienced difficulty in developing their own applications and they are generally regarded as having lower level of computer literacy. This is also supported by Cragg and Zinatelli (1995) who observed that most users in small businesses are classified as non-programming users and relied on packaged software and external sources for application development. Limited financial resources, low IS knowledge and skills, lack of internal expertise and time constraint are found to be the factors inhibiting user-developed application in small businesses. However, Kagan et al. (1990) found that as the need to write the firm's own software increases the level of software sophistication also increases. This is a good indication to encourage small firms to venture into application development despite the difficulty in adopting EUC, as there is tendency to evolve from the fairly simple applications such as word processing and payroll to spreadsheet and inventory control. Later this evolution could take the form of more sophisticated software applications such as telecommunications, database and decision modelling.

There have also been studies concerning the measurement of EUC satisfaction, success and effectiveness. Doll and Torkzadeh (1988) developed an EUC satisfaction (EUCS) instrument to measure end-user's satisfaction with their information systems as substitute for the more traditional data processing measurement of user information satisfaction with their information systems. Igbaria (1990) developed a structural equation model of EUC effectiveness that includes tasks performed, computer usage, end-user satisfaction and perceived effectiveness as the measuring variables. Etezadi-Amoli and Farhoomand (1996) later developed an instrument that measures EUCS based on user performance. Recently, Palvia (1996) developed an instrument to measure user satisfaction in the small business context in recognition of the specificity of small businesses. Common dependent variables identified in these studies include information content, accuracy, format, ease of use, timeliness, software adequacy and maintenance, security and integrity, vendor and external support, work quality, job satisfaction and requirements.

3.3. BENEFITS AND RISKS OF END-USER COMPUTING TO SMALL BUSINESS

The benefits and risks of EUC to small businesses have been well documented (Amoroso and Cheney, 1992; Guimaraes and Igbaria, 1996; Alavi and Weiss, 1986; Frank, 1988; Cale, 1994; Edberg and Bowman, 1996; Floyd et al., 1995; Panko, 1998). Many of these studies contend that the risks of EUC could be potentially lethal to a small firm. However the fact that EUC has been pervasive and continue to grow in small businesses tells much about the benefits of EUC rather than its risks. This phenomenon could be attributed to several reasons. Firstly the risks could be unrealistic and over-zealously reported involving isolated cases. Secondly firms have taken the necessary precautionary steps to avoid the risks in light of these studies. Thirdly these risks could act as a 'time-bomb' waiting to explode and even if they do explode they may go unnoticed in firms that are ignorant of IT and EUC in particular. Lastly but not least firms may realised the many benefits of EUC may outweigh its risks and therefore they are willing to take the chance. No matter what the reasons are recognising the benefits and risks of EUC are necessary for a complete understanding and discussion of EUC in small businesses.

3.3.1. Benefits of EUC

As reported by Amoroso and Cheney (1992) the benefits of EUC are not only specific to the end-users. The benefits also go to the management and the IS staff and IS department. Many of these benefits are similar and cited in other studies as well (Guimaraes and Igbaria, 1996; Alavi and Weiss, 1986). Though these studies were based on EUC in large organisations, lessons could be learnt for small businesses as well. Whilst benefits to IS organisation such as minimised application development backlog, decreased in IS spending, improved programmer productivity, and improved IS and end-user relations (Amoroso & Cheney, 1992; Guimaraes & Igbaria, 1996) are typical to the traditional large firm set-up, other benefits may also be applicable to small businesses. These include better decision-making, improved in end-user computer literacy, more satisfied end-users, faster response to information requests, direct end-user control of data and information, and increased in end-user productivity. Additional benefits include overcoming the shortage of IT professionals (Alavi and Weiss, 1986), and encourage innovation with less IS bureaucracy (Robson, 1994).

Within the specificity of small business Raymond (1987) described several benefits of EUC which in addition to some of the above include lower IT investment, less dependent on vendors for application development, lessen the need for hiring IT personnel, and as an alternative to buying packages. Furthermore, as EUC do not require additional financial and human resources and the fact that today's software is becoming user-friendlier, EUC seems to be more appropriate for small businesses (Raymond and Bergeron 1992). In addition, due to the assimilation of IT in most tertiary and training institutions, firms are more likely to hire graduates with higher computer literacy than they were in the past, making EUC in small businesses more practical.

EUC can be seen to be a "natural" solution to the limitations faced by small businesses in respect of effective utilisation of their IT resources. It is the nature of small businesses to be 'poorly' resourced, and since EUC does not require the presence of internal IT expertise, users with EUC skills would be capable of developing applications appropriate to their needs with no support from the IT professionals. Furthermore due to the specificity of small business with lack of IT expertise, the gulf between IT specialists and EUC practitioners that may be present in large organisations is no longer an issue in small business. With EUC there is no need to hire dedicated programmers or analysts to develop applications and make effective use of IT resources. As EUC evolves within the firm, users become less dependent on third parties and they will be in a better position to evaluate alternatives to IT adoption such as outsourcing, acquiring packages, or develop their own application. EUC could give added flexibility to small firms to adopt IT as it allows more choice for IT adoption resulting in more flexible approach to effective use of IT.

3.3.2. Risks of EUC

Alavi and Weiss (1986) made a comprehensive and widely cited study of EUC risks. The authors identified potential organisational risks associated with EUC in different stages of the end-user development life cycle and suggested suitable control mechanisms to manage these risks. In the analysis stage the risks identified include no proper analysis on acquisition of end-user tools and lack of analysis on application requirement. This result in ineffective investment in end-user tools, incompatible software, risks of security and integrity of data, not enough time spent on problem diagnosis and identifying systems requirements, and solving the wrong problem. This finding is also supported by Brancheau and Brown (1993) who found EUC tend to promote incompatible end-user applications, threats to data security, integrity and privacy due to lack of development methods and knowledge of data management, and ineffective use of financial resources when investing in end-user tools, hardware and software. Janvrin and Morrison (1996) agree that EUC will encourage applications developed without regards to any requirements analysis and design and does not follow any structured methods resulting in more errors and less user confidence. The authors also found that end-user developers tend to spend very little time in planning, and problem definitions and diagnosis. Amoroso and Cheney (1992) found "solving the wrong problem" to be one of the risks associated with EUC. This is supported by Panko (1998) who suggests that omission errors caused by misdiagnosis of problems has the highest rate of being undetected and "is the most dangerous" of errors. The author further suggests that only few organisations have policies on end-user development that caused end-user (spreadsheet) developers to disregard the use of rigorous development disciplines. This lack of development methods and techniques seems to pose consistent risks in EUC and were also echoed in other studies (Amoroso and Cheney, 1992; Edberg and Bowman, 1996; Floyd et al., 1995; and Guimaraes and Igbaria, 1996).

In the design stage among the organisational risks identified by Alavi and Weiss (1986) were no documentation, lack of user tests, lack of quality in applications, development time not spent wisely, and redundant efforts on similar development tasks. Other studies also found unreliable systems due to lack of QA procedures (Brancheau and Brown, 1993; Floyd et al. 1995), no reviews and validation on developed applications (Janvrin and Morrison, 1996), and lack of documentation and testing (Cale, 1994; Edberg and Bowman, 1996). One other risk in the design stage may include frequent changes in the application design due to lack of development standards and procedures (Floyd et al. 1995).

Alavi and Weiss (1986) categorised EUC risks identified in the implementation stage in terms of the operation and maintenance of end-user applications. In the operations of end-user applications among the risks include threats to the security and integrity of data (similar to analysis stage), and putting additional burden to the corporate computing resources. Frank (1988) found that user departments lacked control of file backup, off-site storage and physical access to sensitive files with lack of control against fire hazards to PC files as the most serious risks of EUC. Other related findings include tendency of EUC to create pockets of isolated personalised information systems across departments as opposed to an organisational information systems (Brancheau and Brown, 1993). In addition end-user developed applications tend to be in conflict with the overall organisational objectives, and EUC tend to withheld valuable information to the knowledge of the organisation at the same time retain data which is of little value (Floyd et al., 1995).

For maintenance of end-user applications, failure to document and test changes and failure to upgrade applications are the two EUC risks identified in the Alavi and Weiss study. In addition organisations could also incurred loss of investment in "personal" applications when the individual end-user that develops the applications leave the organisation (Floyd et al. 1995). Other implementation risks identified include poorly maintained applications, corruptible corporate data, strained IS-user relationships, information overloading, and lack of integration between end-user and corporate applications (Guimaraes and Igbaria, 1996).

In studying individual end-user developer risks Panko and Sprague (1998) found that all studies of spreadsheet errors they encountered are not error-free with the number of errors not acceptable in practice. The authors report between 20% to 40% of all spreadsheet models contain errors and found omission errors to be the most common with more than half of all errors. Logic errors were also numerous but mechanical errors were significantly less. The authors suggest only systematic code inspections in groups/teams are able to reduce development errors and minimised individual risks at an acceptable level. However this study has only examined spreadsheet development within the context of EUC risks. Studies should also be done to examine EUC risks in other end-user developed applications using non-spreadsheet development tools such as word processing, databases, application generators and other fourth-generation languages.

Though none of these studies examined the risks of EUC within the specificity of small businesses it is assumed that most of the risks mentioned are also applicable to the small business environment. Nevertheless it would be in the interest of IS management in small businesses for separate studies done on EUC risks and outcomes within the specificity of small businesses to contribute to the wealth of knowledge in this area.

3.4. MODELS OF END-USER COMPUTING

Various models of EUC have emerged especially within the last ten years as evidence of its relatively recent development. Most of the studies are exploratory in nature where the models are used to represent causal relationships between factors identified from the more general IS/IT area. Generally these studies can be broadly categorised into two with both largely based on empirical data employing the survey methods.

The first category belongs to those studies that examined certain predictors or determinants of EUC outcomes. Bivariate analysis for hypotheses tests using correlation and regression analyses were commonly used to determine individual links with the associated outcome. Often a multivariate structural path analysis was further done to assess both the structural components and the corresponding measurement components (outcome) of the model.

The second category of studies was largely focussed on developing instruments for the measurements of EUC outcomes. Common methods used include factor analysis and other structural path analyses such as PLS and LISREL to assess the measurement constructs and analyse the model as a whole. The following are descriptions of the various EUC models taken from the literature.

3.4.1. Determinants of EUC Outcomes

Rivard and Huff (1988) examined the factors that determine the success of EUC based on previous IS success studies. The authors suggest that the instrument used to measure User Satisfaction with IS can also be used to measure EUC success. A model of EUC satisfaction was developed (Figure 3.1) based on factors identified from previous IS studies. Among the factors found to determine EUC success were end-user satisfaction in terms of independence from DP, support from DP and conduciveness of the EUC environment. Other factors include more user-friendly tools and end-user attitudes towards EUC influenced by the degree of their computer literacy, and the degree of DP push as a result of DP's proactive change for EUC support.

Figure 3.1. End-User Computing Satisfaction Model (Rivard and Huff, 1988)

Igbaria (1990) developed a model of EUC Effectiveness using End-user satisfaction, Computer usage and Perceived effectiveness of end-user's jobs as the main indicators of EUC effectiveness. The author found certain individual end-user variables such as end-user training, computer experience and attitudes towards EUC to influence EUC effectiveness. Other factors found to be significantly related to EUC effectiveness include Organisational support, both in terms of management and information centre supports, and Task characteristics represented by task structure (ie. routine and repetitiveness of tasks) and task variety. Figure 3.2 below shows the overall structural model depicting these relationships including the relationships with other antecedent variables.

Figure 3.2. End-User Computing Effectiveness Model (Igbaria, 1990)

Lawrence et al. (1995) developed an EUC Effectiveness and Scope Model within the end-user domain. The authors found a number of factors at the individual level that contribute to EUC effectiveness. These are User IT Sophistication that represents the IT skill and experience of end-users, Business Precision and EUC tool support. Business Precision represents the users' business and IS knowledge and their role and authority with regards to EUC. The authors further suggest better end-user empowerment by providing tool support to facilitate development and introduced the concept of Computer Aided User System Evolution (CAUSE). Figure 3.3 below shows the factors contributing to EUC effectiveness.

Figure 3.3. EUC Effectiveness and Scope Model (Lawrence, et al., 1995)

Brancheau and Brown (1993) presented a comprehensive model of EUC management comprising of four main components based on accumulated theories found in the EUC literature. Over 90 articles on EUC from leading journals were used across a period of ten years from 1983. The primary components are the organisational and individual components that are further divided into Strategy, Management Action and Technology; and individual End-user, End-user Action, Task, and End-user Tools, respectively. The other two are antecedents (context component) consisting of External, Organisational, Workgroup, and Technology Investment, and consequences (outcome component) representing different levels of the organisation, workgroup, individual and application. Conceptually, the primary components represent the "behaviour" of the model that is of significant interest and able to extend the body of knowledge in this area. Interestingly a common theme that appears across the main components of the model is the technology issue, namely the technology factor in the organisation component, the end-user tools in the individual component, the technology investment in the context component, and end-user application in the outcome component. The overall model is shown in Figure 3.4 below.

Figure 3.4. EUC Management Research Model (Brancheau and Brown, 1993)

In a study to evaluate the use of structured design methodology by end-users Janvrin and Morrison (1996) found several factors influencing the risks and outcomes in EUC. Risk factors found to be significant are broadly categorised into two, developer attributes and development approach. Developer attributes particularly gender, domain expertise and application expertise are found to significantly influenced EUC outcomes specifically error rates. Using MANOVA analysis to test interactions between different treatment groups and development approaches on error rates and other EUC outcomes the authors found the groups using structured design technique demonstrated significantly lower error rates and lesser development time than the ad-hoc design group. Figure 3.5 shows the research model with all the significant risk variables and the EUC outcomes.

Figure 3.5. Model on EUC Risks and Outcomes (Janvrin and Morrison, 1996)

A model of EUC policy compliance was developed by Galletta and Hufnagel (1992) on the premise that a formal EUC policy statement and compliance of the policy by end-users would encourage successful management of EUC. The authors adopt organisational context as antecedent factors and examined the linkages between these factors and (1) the process involved in developing and administering EUC policies and (2) the policy content itself in terms of its comprehensiveness and restrictiveness. In addition links were also established between these two process variables and policy content with EUC policy compliance. A description of these linkages is shown in Figure 3.6 below in the form of a contingency model of EUC policy compliance.

The results show significant links exist between organisational variables and the policy process and to a lesser extent the policy content. A process variable in the form of a formal EUC planning is influenced by a series of organisational variables. These include proximity of the MIS level in the management hierarchy, existence of a

Figure 3.6. A Model of EUC Policy Compliance (Galletta and Hufnagel, 1992)

Aston University

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MIS plan, alignment of the IS plan with the strategic business plan, interest in EUC, and positive EUC growth/maturity (sophistication). Formal EUC policy documentation (process variable) and comprehensive EUC policy statements (content variable) are present in organisations with bureaucratic orientations and exhibit positive EUC interest. Organisations new to EUC would tend to possess more formal policy in EUC training, and organisations with interest in EUC and encourage EUC growth tend to have more formal mechanisms for monitoring compliance with EUC policy. Lastly a more comprehensive and restrictive EUC policy tend to be associated with higher compliance with EUC policies. A major setback of this model however is its focus of study is specifically for large companies listed in the Fortune 500. However it could provide some insight to small firms in their formulation of EUC policies despite the fact that small firms lacked any forms of policy and planning as has been discussed previously.

3.4.2. A Model of EUC in Small Business

The lack of EUC study in small business could be further substantiated by the lack of EUC model in the specificity of small business. The main reason is probably attributed to the assumption made by these prior studies that their models are applicable to all types of organisations irrespective of size. This however contradicts earlier claims by Ein-Dor and Segev (1978) and Attewell and Rule (1991) that research findings on MIS in large firms cannot be generalised to small firms. Previous discussions and studies also show that there are significant differences between small and large firms both in terms of the business and IS environment (DeLone, 1981; Ein-Dor and Segev, 1982; Cragg and Zinatelli, 1995; Julien, 1995; Igbaria et al., 1997). Perhaps this continued lack of EUC studies in small business explained the current EUC ranking as the third most important IS issues in small business (Pollard and Haynes, 1998). This is consistent with the arguments suggested by Palvia et al. (1996) that the decline in EUC ranking (among samples of large firms) was attributed to the majority of the EUC issues have been addressed by the numerous literature on the subject. Therefore in the light of these arguments more studies should be encouraged to examine the EUC models within the specificity of small business in order to study the differences and contribute to the knowledge and understanding of the EUC phenomenon in small business.

One of the few and perhaps the earliest EUC model in small business was the one developed by Raymond (1987) who explored the presence of EUC in small business. Two factors were investigated as important conceptual constructs related to the presence of EUC in small firms, namely organisational and IS constructs. Discriminant analysis was employed to determine the construct variables that distinguish firms with EUC from those firms without EUC. Six variables met the discriminating criterion and significantly contributed to the presence of EUC. They were IS complexity (sophistication), EDP resources, IS autonomy, organisational structure in terms of decentralisation and number of IT professionals, and organisational maturity in terms of formal structure, documentation and policies. In addition a bivariate correlation analysis was conducted to test individual hypotheses of each construct variables with the presence of EUC. Two organisational variables namely organisational size (employees and sales turnover) and organisational structure (decentralisation) were found to be significantly related to the presence of EUC. Four IS construct variables were also significantly related to the presence of EUC. They were EDP resources, IS autonomy, application portfolio, and IS complexity which confirm most of the findings in the discriminant analysis. Results of the findings are represented in the model of the presence of EUC in small business as shown in Figure 3.7 below.

Figure 3.7. Model of the presence of EUC in small business (Raymond, 1987)

3.4.3. Measurement of EUC Outcomes

There have also been studies concerning the measurement of EUC outcomes, namely EUC satisfaction/success, EUC effectiveness, and EUC sophistication. Doll and Torkzadeh (1988) developed an EUC satisfaction (EUCS) instrument to measure end-user's satisfaction with their information systems as substitute for the more traditional data processing measurement of user information satisfaction with their information systems. Using a factor analysis technique a 12-item instrument was generated and factor analysed into five components - content, accuracy, format, ease of use and timeliness. Content refers to the information content generated by the end-user application and measures the degree to which the information meets the needs of the application's recipients. Accuracy deals with the accuracy of the application to produce satisfactory results. Format is use to measure the presentation and clarity of the output. Ease of use refers to the user-friendliness of the application. Timeliness is use to gauge 'on time' and up-to-date information.

Etezadi-Amoli and Farhoomand (1996) later developed an instrument that measures EUC Satisfaction (EUCS) based on user performance. Factor analysis was employed resulting in six measurement factors of EUCS. These were documentation, ease of use, functionality of system, quality of output, support and security. These factors were then related to user performance using structural equation modeling. The statistical package LISREL was employed to assess the significance of the structural relationship between the EUCS measurement factors and the outcome variables that measure user performance. User performance is measured based on work quality, ease in performing job, time saved, and meeting job requirements. This instrument can be used to investigate the effect of users' satisfaction on their performance with the applications they themselves developed.

Recently, Palvia (1996) developed an instrument to measure user satisfaction in the small business context. Variables from previous user information satisfaction and EUCS instruments were used and subjected to a series of reliability and validity assessment using Cronbach's α and correlation analysis. A final factor analysis was conducted on the variables resulting in a 12-item measurement construct. The items include software adequacy, software maintenance, information content, information accuracy, information format, ease of use, timeliness, security and integrity, productivity, documentation, vendor support, and training and education. Based on this finding the author concurs with the specificity of the small business construct as more than half (57%) of the item variables were not present in the previous instruments.

3.5. END-USER COMPUTING SOPHISTICATION

Among studies in the EUC area, studies on EUC sophistication are comparatively much fewer and relatively more recent. There is a need to assess the EUC phenomenon in firms in order to examine the extent to which end-users developed their own applications, both in terms of the nature of the applications itself and the capabilities and behaviors of the end-users. This concept of EUC sophistication was initially limited to focussing on the nature of end-users themselves. Earlier studies examined characteristics of end-users and the complexity of EUC activities they performed (Rockard and Flannery, 1983) and later combining these with the behavior of end-users and their abilities forming a concept commonly known as "end-user sophistication" (Cotterman and Kumar, 1989; Marcolin et al., 1993). However according to Blili et al. (1996) "end-user sophistication" is not the same as EUC sophistication but form part of the EUC sophistication measurement construct. According to the authors, EUC sophistication consists of three dimensions namely

End-User Sophistication, Application Sophistication, and Usage Sophistication. End-User Sophistication refers to the individual end-user's technical capability as defined by Rockart and Flannery (1983) in their six-level user typology as described earlier. These are non-programming end-users, command-level end-users, end-user programmers, functional support end-users, EUC support personnel, and data processing programmers. Application Sophistication concerns the nature and type of applications developed by end-users. Applications are seen as having varying degrees of complexity with certain types of applications believed to be more sophisticated than others. Usage Sophistication refers to the frequency of use of such applications with the more frequently used applications being claimed to be more sophisticated.

Figure 3.8. Measurement of EUC Sophistication (Blili et al., 1996)

Figure 3.8 shows the overall construct of the EUC sophistication measurement with the underlying variables for each of the dimension. However the sample data used in Blili et al. (1996) was from large organisations with established information centres and DP departments with no representative sample from the small firms.

Zinatelli et al. (1996) came closer to this study by identifying organisational factors, both intra and extra-organisational factors influencing EUC sophistication and EUC success within the specificity of small business. The authors identified several variables for both the factors in addition to measurement variables for both EUC sophistication and EUC success from review of related literature. Intra-organisational factors consist of computer experience, computer training, EUC tools, internal EUC support, task structure, and top management support. External EUC support constitute the extra-organisational factor.

The authors defined EUC sophistication as the capability of end users to perform EUC activities and defined four dimensions as measurement for EUC sophistication. Two dimensions are similar to Blili et al. (1996) namely application utilisation (application sophistication) and end-user type (end-user sophistication). Two other dimensions identified were breadth of end-user skills and knowledge, and finesse in terms of capability to learn to use new software. These latter dimensions could be categorised as the characteristics of end-users in terms of their abilities and behaviour, and using the preceding arguments should also belong to the end-user sophistication dimension. Nevertheless the four dimensions of EUC sophistication were used by Zinatelli et al. (1996) and a case study research strategy was employed. Using the pattern matching technique the dimensions were found to be relevant for EUC sophistication in small firms. Patterns examined across cases revealed additional variables that were absent in the initial model but found to be significantly related to EUC sophistication and success.

Figure 3.9. A Model of EUC Sophistication and Success in Small Firms (Zinatelli et al., 1996)

The revised model of the research finding is presented in Figure 3.9. Zinatelli et al. (1996) conclude that EUC sophistication is an intermediary factor both as an outcome influenced by intra and extra-organisational factors and an antecedent or a determinant affecting EUC success in small firms.

Combining previous studies of IT sophistication and EUC sophistication it appears that application sophistication is a common factor used to measure IT-related sophistication. It could be argued that a fairly sophisticated and complex application would require a fairly sophisticated end-user with sufficient breadth of skills and knowledge. Likewise, a simple query for example can be easily developed by less sophisticated end-users with minimal IT skills and knowledge. Obviously this later category of end-users would not think of developing the former, more sophisticated application with high success. Similarly, these complex applications are more likely to be used on more sophisticated IT equipment and utilised by a more sophisticated IT resource. On the basis of these arguments, application sophistication is used as a construct for both IT Sophistication and EUC Sophistication in this thesis. An instrument developed by Kagan et al. (1990) to measure IT sophistication in small firms discussed earlier in Section 2.5 was adopted for this purpose.

For EUC sophistication, in addition to application sophistication, end-user sophistication will also be used as a second construct as suggested previously by Blili et al. (1996) and Zinatelli et al. (1996) and illustrated in figures 3.8 and 3.9, respectively. For this purpose, a modified end-user typology is used for small business application development. As discussed previously in section 3.1, the end-user typology developed by Rockart and Flannery (1983) (also used by Blili et al., 1996 and Zinatelli et al., 1996) is not applicable in small business characterised by lack of formal IS structure, no IT expertise and limited end-user support. For example, *Functional Support Personnel* (sophisticated programmers), *EUC Support Personnel* and *DP Programmers* defined in the Rockart and Flannery (1983) typology would not be relevant in this context. This is exemplified in the Zinatelli et al. (1996) study where none of the most sophisticated end-user typology identified in all the firms studied has even reached the *Functional Support Personnel* or higher category. The rationale is a "non-programming end-user" can become a sophisticated end-user developer using today's 4GLs and application development generators to develop sophisticated applications. Therefore, as suggested by Dahalin and Golder (1998b) three types of end-users were identified, namely *simple end-users*, *command level end-users*, and *end user-developer* to much more represent the small business context.

A third construct, number of users using the applications was used as a measure for Usage sophistication. This is because previous studies have consistently found that the number of employees or users contributes to the firm's use of IT and IS success (Raymond 1987, Kagan et al. 1990, Lai 1994). It is suggested that the larger the number of end-users using the applications developed by themselves, the greater the degree of usage of the applications in terms of duration, frequency and number of end-user activities.

Either measurement developed by Blili et al. (1996) or Zinatelli et al. (1996) could not be used in this study to measure EUC Sophistication. Using either measurement would require changes to the aims of the study, the scope of research, data collection techniques and research strategy. This is necessary in order to accommodate individual end-users' responses, large firms with established DP and IC support structures (Blili et al., 1996), and a measurement based only on evidence from observation (Zinatelli et al., 1996).

Blili et al. (1996) based their study on large firms (five financial institutions with averages of 18,240 employees and $48 billion assets) and some of the measurement variables were not applicable in a small business set up. Example, the inclusion of mainframes in DP department set ups, ICs to support EUC, and application developed by vendors and internal IT specialists as part of the measurement variables are clearly not relevant in this study. Moreover Palvia (1996) contends that measurements used for large organisations are not applicable to small business. In his study of EUC Satisfaction measurement for small business, the author found significant differences between his measurement and those developed by Doll and Torkzadeh (1988) and others (Bailey and Pearson, 1983; Ives et al., 1983) who used large organisations with established DP and end-user support services.

Whilst Zinatelli et al. (1996) used small firms to measure EUC Sophistication, the measurement variables used were based on earlier works by Blili (1992) and Marcolin et al. (1992; 1993). The later, according to Blili et al. (1996) refer to the study of end-user's competence (ie. user aptitude and abilities) at a given time. This, according to the author, is more applicable to the concept of EUC maturity (or evolution) than EUC Sophistication. This was later confirmed by Munro et al. (1997) who extend their earlier notion of End-User Sophistication to measuring user competence. In addition, Zinatelli et al. (1996) themselves contend that their model could not be generalised since their findings were based on case study evidence.

Under these circumstances it was thought appropriate that a new measurement for EUC Sophistication in small business should be developed where its construct should be based on related studies such as Blili et al. (1996), Zinatelli et al. (1996) and others discussed in this section. The three EUC Sophistication constructs that will be used in this study are summarised as shown in Figure 3.10 below. Though the constructs are consistent with the Blili et al. (1996) model for measuring EUC sophistication, the actual measurements were taken from different sources to adapt to the small business environment. Whilst Blili et al. (1996) made use of a sample from large businesses, sources for all three constructs used in this study are based on samples taken from small firms. This is to ensure that the EUC Sophistication construct used in this study is representative and relevant to small business as discussed earlier in this section.

Figure 3.10. EUC Sophistication Construct for Small Business
(Adapted from Blili et al. 1996)

Application Sophistication

- Software Sophistication Index (SSI)
  (adapted from Kagan et al. 1990)

End-User Sophistication

- End-User Typology
  (modified from Rockart & Flannery 1983
  adopted from Dahalin & Golder 1998b)

Usage Sophistication

- Number of application users
  (adopted from Raymond 1987, Lai 1994)

In the Application Sophistication construct of Figure 3.10, the Software Sophistication instrument developed by Kagan et al. (1990) discussed earlier in Section 2.5 will be used. However, a re-calibrated measurement will be used that will only be based on applications developed by end-users. Operationalisation of the sophistication index and formulation of the re-calibrated instrument are discussed in detail in Section 5.2.

For End-User Sophistication construct, the three types of end-users mentioned above will be used. For each firm that has EUC presence, the most sophisticated end-user will be determined based on predefined criteria present in the questionnaire. This includes the development tools used, types of software to develop the application and the nature of the application being developed. The information gathered will be matched against the category of end-user that best fits the end-user typology description discussed previously in this section and in section 3.1.

Finally, the Usage Sophistication construct as discussed earlier in this section will be based on the total number of end-users using the user-developed applications.

On the basis of the Software Sophistication construct developed by Kagan et al. (1990) discussed in Section 2.5, an IT Sophistication construct has also been developed and summarised in Figure 3.11 below. The Software Sophistication Index (SSI) is a measurement taken directly from Kagan et al. (1990) and is based on computerised applications, systems software and other IT products maintained by the firms.

Figure 3.11 IT Sophistication Construct for Small Business (adapted from Kagan et al. 1990)

- Software Sophistication Index (SSI)

3.6. SUMMARY OF EUC AND RELATED STUDIES

A summary of the literature on EUC discussed in this study is presented in Table 3.1 below. Review of the related literature is based on published articles in the areas of EUC in both large and small businesses. More than 70 articles were reviewed from over 20 IS journals from 1983 to 1996. These journals are considered to be significant academic and practitioner journals by researchers conducting studies of IS key issues and studies on EUC (Palvia et al., 1996; Brancheau and Brown, 1993; Grover et al. 1996). Issues were identified on the basis of the related areas appearing in these journals to form the model of EUC Sophistication for small business. As studies of EUC in small business are very limited, most of these issues form conjectures and hypothetical views derived from the other related areas including IT in small business as discussed in the preceding chapter.

Among the main issues identified to have relevance to the EUC study in small firms include Management, Technology, Organisational issues, Behavioural issues, Quality, Risks, Strategy, External Support, and EUC outcome. EUC outcomes include EUC Sophistication, EUC Satisfaction, EUC Success and EUC Effectiveness. For the purpose of this study the scope covers issues related to Management, Technology, Organisation and Behavior with EUC Sophistication as the outcome. In addition IT Sophistication is also included due to the specificity of small firms with respect to IT adoption. Issues on Quality, Risks and Strategy are considered as part of the Management issue whilst External Support is an Organisational issue. These issues form the basis for the construction of the Initial Model of EUC Sophistication in small business, which will be dealt with in the next section.

Table 3.1. List of Journals and Articles Cited with Summary of Related Areas

Journal Name	Authors	Related Areas
1. Journal of End-User Computing	Aggarwal (1994); Blili, Raymond & Rivard (1996); Lane, Palko & Cronan (1994).	Technology, organisation & people factors; EUC sophistication; EUC Satisfaction.
2. MIS Quarterly	Brancheau, Janz & Wetherbe (1996); Brancheau & Wetherbe (1987); Cragg & King (1993); De Lone (1988); Dickson, Leitheiser, Wetherbe & Nechis (1984); Doll & Torkzadeh (1988); Montazemi (1988); Niederman, Brancheau & Wetherbe (1991); Raymond (1985).	EUC as IS issues; EUCS measurement; Pros and cons of small firm computing; Organisation & people factors in small firm computing; IS success in small businesses; IS satisfaction in small businesses.
3. Journal of Systems Management	Cale (1994); Dodd & Carr (1994); Floyd, Walls & Marr (1995); Frank (1988); Gibson & Hughes (1988); Gupta & Harris (1989); Harris, Matthew & Alston (1995); Lederer & Spencer (1988); Karten (1987); Lees (1987); Lees & Lees (1987); Munro & Huff (1988); Nord & Nord (1994); Podorowsky (1988); Saarinen, Heikkila & Saaksjarvi (1988); Spence (1988).	Quality issues for EUC; System development led by end users; guidelines for user/system developer; EUC management; end-user training; type of EUC application; EUC in small businesses; EUC support through ICs; Human interface in EUC; DSS package to assist small business; strategies for EUC growth.
4. DATA BASE	Amoroso & Cheney (1992); Raymond (1990a).	Quality issues in EUC; EUC in small businesses.

5. Journal of MIS	Alavi & Weiss (1986); Alavi, Nelson & Weiss (1987); Edberg & Bowman (1996); Lee, Kim & Lee (1995)	EUC strategies; risks; quality; training
6. International Journal of Information Management	Blili & Raymond (1993)	IT strategy for SMEs
7. ACM Computing Surveys	Brancheau & Brown (1993)	EUC management
8. American Journal of Small Businesses	Cooley, Walz & Walz (1987)	IS success in Small Businesses.
9. Information & Management	Chan & Storey (1996); Chau (1995); Cragg & Zinatelli (1995); Culpan (1995); Etezadi-Amoli & Farhoomand (1996); Grover, Jeong & Segars (1996); Igbaria & Zviran (1996); Khan (1992); Lai (1994); Mykytyn & Green (1992); Ngwenyama (1993); Palvia (1996); Palvia, Means & Jakson (1994); Raymond & Bergeron (1992); Salchenberger (1993); Schiffman, Meile & Igbaria (1992); Soh, Yap & Raman (1992); Torkzadeh & Doll (1993).	IS sophistication & success in small businesses; package software; EUCS measurement; EUC success in small businesses; documentation in EUC; EUC methods; Structured method in EUC; UIS Satisfaction in small businesses; Consultant effectiveness; determinants of computing in small businesses; IS effectiveness; Attitudes.
10. OMEGA International Journal of Management Science	Doll & Torkzadeh (1990); Igbaria (1990); Igbaria & Zviran (1991); Thong & Yap (1995); Yap, Soh & Raman (1992); Raghunathan & Raghunathan (1991).	Measure of EUCS; EUC success & effectiveness; IT adoption in small businesses; IS success.
11. Journal of Systems Software	Doukidis, Lybereas & Galliers (1996).	Information strategy planning in small businesses.
12. Information Resources Management Journal	Guimaraes & Igbaria (1996).	EUC success.
13. Journal of Business Venturing	Julien (1995).	IT in small businesses.
14.Entrepreneurship Theory & Practice	Kagan, Lau & Nusgart (1990).	IS Usage in small businesses.
15. Journal of Computer Information Systems	Magal & Lewis (1995).	IT success in small businesses.
16. Journal of Small Business Management	Malone (1985); Raymond (1988).	IS success in small businesses; EUT in small businesses.
17. Information Systems & Operations Research	Montazemi (1987); Raymond (1987).	IT adoption in small businesses; EUC in small businesses.
18. Communications of the ACM	Huff, Munro & Martin (1988); McLean, Kappelman & Thompson (1993); Rivard	EUC success; End User Typology; EUC growth stages; Key issues of EUC.

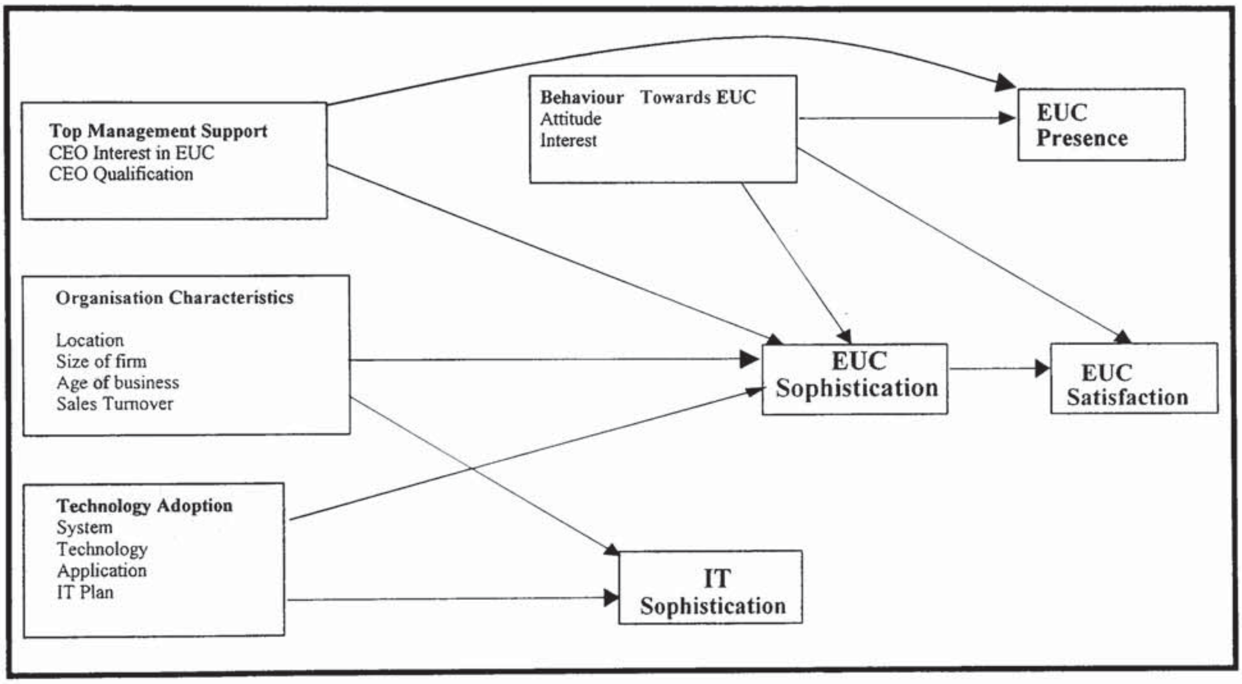
	& Huff (1988); Rockart & Flannery (1983).	
19. European Journal of Information Systems	Zinatelli, Cragg & Cavaye (1996).	EUC sophistication & success in small businesses.
20. Information Systems Research	Thong, Yap & Raman (1996).	Top management & External support in small businesses.
21. Proceedings of 29th Annual Hawaii International Conference on Systems Sciences	Janvrin & Morrison (1996).	EUC risks.
22. 1996 Information Systems Conference of New Zealand	Hale & Cragg (1996).	IS strategy for small firms.

3.7. INITIAL MODEL OF END-USER COMPUTING SOPHISTICATION IN SMALL BUSINESS

A number of models relating to EUC were reviewed in sections 3.4 and 3.5. Whilst these models have addressed the issues of EUC success and satisfaction, EUC effectiveness, and EUC management, there have been relatively less studies concerning EUC sophistication particularly within the context of small business. Though the models developed by Zinatelli et al. (1996) and Blili et al. (1996) are most appropriate to the present study, the former did not addressed the technology adoption issues, which are important in most studies on EUC such as suggested by Brancheau and Brown (1993) and Raymond (1987). Blili et al. (1996) developed an instrument to measure EUC sophistication but tested their instrument using samples from large firms. Whilst Zinatelli et al. (1996) made use of case study research to investigate the factors affecting EUC sophistication (therefore no specific EUC sophistication measure was developed), Blili et al. (1996) did not study the effect their EUC sophistication measure has on the contributing factors and other EUC issues.

Clearly there is a gap in which an EUC sophistication measure relevant to small business was not available and among other important IS issues, technology adoption has not been addressed in relation to EUC sophistication in small business. This research attempts to fill this gap by creating a new model to complement the works by Zintelli et al. (1996), Blili et al. (1996) and the other related studies discussed in the current and preceding chapters. The idea is to develop the model inductively in order to identify the issues and factors, and by adapting the EUC sophistication measurement developed by Blili et al. (1996) the effects these issues and factors have on EUC sophistication in small business can be studied objectively. This new model is presented in Figure 3.12 in the form of the Initial Model of EUC Sophistication in Small Business. Operationalisation of the underlying research variables that form the issues and factors in the model will be discussed in Chapter 4.

Figure 3.12. Initial Model of End-User Computing Sophistication in Small Business



Many studies on IT Adoption and IS Success suggest top management support, organisational characteristics, and technology adoption as important factors for technology assimilation within the small business (DeLone, 1988; Kagan et al., 1990; Magal and Lewis, 1995; Raymond, 1990b; Thong and Yap, 1995; Thong et al. 1996; Yap et al 1992). Discussions on these issues from these studies and many more have been mentioned in this chapter as well as the previous chapter.

Support from owners or top management of small firms is of paramount importance for IT to be introduced into the business (DeLone, 1988; Thong et al., 1996; Thong and Yap, 1995). Equally, top management support may encourage end-user interest in EUC by (1) providing the necessary IT resources such as computers and the appropriate software and development tools; (2) providing training and formal instruction into the techniques and tools for EUC; and (3) offering positive reinforcement for continuous and sustainable EUC activities within the firm. Thong et al. (1996) found that successful IS implementation in small firms is contingent upon top management involvement in the IS projects. In terms of CEO qualification Zinatelli et al. (1996) found that top managers of small firms with university degrees are more receptive to computers and showed greater interest in EUC than those with lower levels of education.

Organisational characteristics such as location, size and age of the business have also been found to influence IT adoption and IS success in small business (Palvia et al., 1994; Raymond, 1987,1990b; Lai, 1994). Lai (1994) posits that there are obvious differences between firms located in the rural and urban areas in relation to IS success in small firms. This is also supported by Palvia and Palvia (1999) who found that firms in the rural areas are less satisfied with their IS compared to their urban counterparts. Raymond (1990b) and Palvia et al. (1994) found that more established small firms with larger employees tend to be more successful in their computer use. Organisation size in particular has been found to influence the presence of EUC in small firms (Raymond, 1987).

Technology refers to the availability of technology to support EUC, which includes technology investment as reflected by the number of IT products and software acquired, platforms used, and technological maturity (Brancheau and Brown, 1993 and Aggarwal, 1994). Through EUC most of the available computer resources can be utilised in the development of applications without having to acquire new software or hardware (Raymond and Bergeron, 1992). Personal computing packages are usually bundled together when a microcomputer is purchased and with today's easy-to-use development tools, developing a simple yet essential application would be a first step in the sophistication of EUC within the small firm.

Behavioural issues are also important as determinants of IT adoption and EUC success, and have appeared in prior studies of EUC involving large firms (Brancheau and Brown 1993, Rivard and Huff 1988). End-user's behaviour refers to the attitudes of end-users towards EUC (Igbaria, 1990) and their awareness of the capabilities and benefits of EUC (Magal and Lewis, 1995). Training and exposure to IT have also been seen to have positive impact on user's attitude and awareness of IT (Raymond, 1988). Likewise, IT exposure and training in EUC can contribute towards positive end-user behaviour, thereby contributing to the effectiveness of EUC. External support may also have a positive impact on end-user behaviour contributing to IS success in small firms.

As mentioned earlier in section 2.5, a measure of IT Sophistication has been described in Kagan et al. (1990), and in section 3.5 different measures of EUC Sophistication were discussed and appeared in Blili et al. (1996) and Zinatelli et al. (1996). The IT Sophistication measurement is based on the number of computerised applications, systems software and other IT products used by the firms. This measurement has appeared in various studies such as Raymond and Paré (1992) and Cragg and Zinatelli (1995) on IT Adoption and IS Usage, and Cragg and King (1993) and Kagan et al. (1990) on the level of Computing and Software Sophistication. For EUC Sophistication measurement, the constructs used by Blili et al. (1996) and Zinatelli et al. (1996) are Application Sophistication, End-User Sophistication and Usage Sophistication as discussed earlier in section 3.5. A modified version of these measures will be used in the form of IT Sophistication Index (ITSI) and End-User Computing Sophistication Index (EUCSI) as described earlier in sections 2.5 and 3.5, and will be elaborated later in Chapter 5.

EUC Presence has been studied by Raymond (1987) using a dichotomous variable to distinguish firms with EUC from those firms without EUC. A similar form of dichotomous variable has been used in other studies for IT Adoption (Thong and Yap 1995). For EUC Presence, Raymond (1987) identified Organisational characteristics and IS characteristics as factors that contributed to the presence of EUC in small business as mentioned earlier in section 3.4.2. Organisational characteristics include firm's size in terms of number of employees and sales turnover, and organisational structure. IS characteristics include Application portfolio, IS complexity, EDP resources, and IS autonomy.

EUC Satisfaction has been studied and appeared in many studies such as Doll and Torkzadeh (1988), Igbaria (1990), Rivard and Huff (1988), Zinatelli et al. (1996), Etezadi-Amoli and Farhoomand (1996) and Palvia (1996). However, EUC Satisfaction has not been studied in relation to EUC Sophistication. EUC Success used as a surrogate measure of satisfaction (Doll and Torkzadeh, 1988) has appeared to be affected by EUC Sophistication (Zinatelli et al., 1996). In addition, no studies have also been found to describe EUC sophistication in relation to IT sophistication and how this relationship is informed by the other technology assimilation factors mentioned in this section.

This study attempts to establish empirical evidence of these relationships through the formulation and testing of a series of hypotheses that will be discussed in the next chapter. The next chapter will also describe the research methods to be used to validate the initial model. The initial model did not include individual characteristics, as these are not within the scope of the research as discussed previously in section 1.3.

This study intends to guide small firms in their EUC strategy formulation by examining issues at the organisational level based on consensus from the collective decision perspective. The factors identified in the initial model such as Top Management Support, Organisational Characteristics, Behavioural issues and Technology Adoption are thought to be relevant for studies at the organisational level. Other organisational context studies such as Galletta and Hufnagel (1992) on EUC policy, Premkumar & Roberts (1999) on IT adoption in small business, and Raymond (1987 and 1990a) on EUC presence and EUC in small business context have also not included individual characteristics. On the other hand studies such as Zinatelli et al. (1996), Lawrence et al. (1995), Igbaria (1990), Janvrin and Morrison (1996), and Panko and Sprague (1998) have examined issues at the individual level. EUC studies, being part of the IS research domain, can focus on Organisation, Individual, Society, Technology, Methodology and Theorem Building and Testing as suggested by Galliers (1992). Strategies in conducting IS research will be discussed in the next chapter.

CHAPTER 4: RESEARCH METHODS

4.0. INTRODUCTION

This chapter describes the research methods used in this study and provides justification for adopting such methods. Alternative strategies in conducting IS research are described to examine the possible approach that can be taken. The overall approach to the research is presented by means of a research framework and details of the methods are discussed with both the survey and case study research strategies chosen for the study. Activities and techniques involved in each method are elaborated and summarised in the respective research frameworks.

The Initial Model of EUC Sophistication in Small Business presented in Chapter 3 was based on the review of literature in the previous two chapters. Each component of the model was discussed and the underlying variables were identified. Relationships established between the components and their underlying variables are defined in this chapter in the form of the research hypotheses. Links between the hypotheses and the research variables are presented and the chapter ends with a discussion of the operationalisation of the variables to be used in the research.

4.1. ALTERNATIVE RESEARCH STRATEGIES

Before discussing the research strategy taken by this study, alternative strategies for conducting IS research are presented to highlight the options available. Following Cavaye (1996) and Galliers (1992), this thesis distinguishes between the terms 'research strategy (approach)' and 'research method'. Both authors have defined research strategy as 'a way of going about one's research, embodying a particular style and employing different methods'. A research method therefore forms part of a research strategy which according to Cavaye (1996) is defined as 'a way to systematise observations, describing ways of collecting evidence and including the type of tools and techniques to be used during data collection'.

Information Systems, according to researchers are multi-disciplinary (Land, 1992; Cavaye, 1996) and a variety of research strategies and methods can be employed in the study of IS issues (Cavaye, 1996; Vidgen & Braa, 1997; Attewell & Rule, 1991). Whilst Galliers (1992) in his taxonomy of IS research approaches identifies several strategies that can be used in IS research, a number of commonly used strategies are identified and also suggested by others (eg. Yin, 1994; Cash & Lawrence, 1989; and Vidgen & Braa, 1997). These include:

- Experimental Research
- Survey Research
- Case Study Research
- Action Research
- Descriptive/Interpretive, History and Archival Research
- Theorem Proof/Mathematical Models
- Software Systems Demonstrations

A review of the literature suggests that a research method can include any of the following:

- Questionnaire
- Pilot Study
- Survey (mail and/or telephone)
- Interviews
- Direct Observation
- Participant-observation
- Archival Records
- Data Transcription
- Document Analysis/Kit Review/Walk-through
- Statistical Packages and other automated tool support

Yin (1994, p. 4) suggests the choice of a research strategy should depend on three conditions, that is (1) research questions, (2) control over behavioural events, and (3) focus on contemporary or historical events. Following the conditions suggested by Yin (1994), it would be appropriate to examine the research questions posed in Chapter 1 in order to justify the research strategy (or strategies) to be used. The three research questions were:

1. To what extent small firms are capable of developing their own applications?
2. Are there differences between firms with different levels of IT sophistication with respect to EUC sophistication?
3. Is increased IT Sophistication a necessary pre-requisite for the development of EUC?

Based on the research questions posed, several forms of queries can be identified. In the first question, "To what extent small firms are capable......" would require understanding of *how* small firms develop their own applications and how far (*how much*) can they go given their limited capability. Using Yin's guideline, the "how" and "why" types of questions are "explanatory" in nature and are more suitable for case study, history and experimental research strategies. On the other hand, forms of research questions involving "how much", "how many", "who", "what", and "where" are more suitable for survey and archival research strategies.

Galliers (1992, p. 160) further suggests that the focus of IS research can either be in the context of Society, Organisation, Individual, Technology, Methodology, or Theorem Building and Testing. Since the focus of this research is at the organisational level, using Experimental Research strategy particularly involving laboratory experiment could be a problem following the guidelines by Galliers & Land (1987). Moreover this strategy would require 'control over behavioural events' as suggested by Yin (1994, p. 6). Therefore Experimental Research strategy would not be appropriate for this research, as it will be difficult to control the way organisations respond to an experiment.

In the second research question, to know whether there are differences between IT and EUC sophistication would require "what" factors that make up the sophistication (ie. the measurement itself). Similarly to answer the third question, whether the development of EUC is contingent upon increase in IT sophistication, would require understanding of the factors surrounding EUC and IT sophistication. That is, "what" are the factors and their relationships with IT and EUC sophistication? Moreover, according to Vidgen & Braa (1997), the ability to *understand* a phenomenon (in this case "the extent of small firms' capability" and "increased EUC sophistication" as defined in the research aim) would require the "power of explanation". Explanatory questions, according to Yin (1994, p.6) are relevant for Case Study along with History and Experimental research strategies. Since the focus of the research is on contemporary events as opposed to historical, History research strategy is also not appropriate for this study.

Whilst Descriptive/Interpretive research may also focus on contemporary events as well as past development (Galliers 1992, p.158), the use of pure intuition as opposed to empirical evidence may not be appropriate in this study. Theorem Proof according to Galliers (1992, p. 155) is more applicable in the technical field of computer science, which focuses on Technology, Methodology and Theorem Building and Testing. Similarly Mathematical Models and Software Systems Demonstrations would fall under this category rather than focussing on Society, Organisation or Individual.

Clearly, the form of the research questions demands a combinations of "what's", "how much" and "how's" questions, which following Yin's guideline is appropriate for Survey, Case Study and Action Research strategies. As discussed in the next section, Action Research requires a long time period and more of the organisation's resources (Vidgen & Braa, 1997) than were possible in this research. So a combination of strategies combining the survey and case study methods was considered.

4.2. THE SURVEY AND CASE STUDY RESEARCH STRATEGIES

The research strategies employed in this study and documented in this thesis are a combination of survey research and case study research strategies. Mixed research strategies combining quantitative and qualitative approaches are acceptable and encouraged by researchers in the IS field (Remenyi and Williams 1996; Attewell and Rule, 1991; Cavaye 1996). Remenyi and Williams (1996) suggest that multiple approaches to IS research can lead to very satisfactory results in particular when both quantitative and qualitative approaches are used. Attewell and Rule (1991) contend that fieldwork such as participant-observation, one of the major sources of evidence for data collection in case study research (Yin 1994, p. 79), is extremely useful *after* conducting a survey to better understand what respondents are saying through survey instruments.

Cavaye (1996) described two approaches to IS research involving multiple strategies. Firstly, in the traditional approach, the first phase involves building of theory, which includes defining the theoretical constructs, identifying relationships and formulating hypotheses. This is accomplished by employing the case study research strategy. The second phase involves using survey research to test the hypotheses and draw deductive conclusions on the population. Alternatively in the second approach it is possible to test theory in the first phase through survey research followed by a case study research in the second phase. The aim is to test existing theory for predictive, generalisable qualities and through the case research to build / discover new constructs, relationships and hypotheses. Cavaye (1996) cites the reasons for combining the methods as "... *it enables the building of a fuller, richer picture* *surrounding a phenomenon* [...] *it enables cross-validation of findings through triangulation* [...] *it helps find explanations for diverging results...*" (Cavaye, 1996).

Since the main aim of this research is to understand the EUC phenomenon in the context of small business, either approach could have been employed. In fact a case study research alone was initially thought to suffice since understanding a phenomenon according to Yin (1994, p.6) is "*more explanatory*" and the best strategy would be case study research where the phenomenon can be explained "*in its real-life context*". On the other hand conducting a survey alone would not have accomplished the same aim though it would help describe a sample of the small business population and its relations to IT and EUC. However the importance of using survey research should not be underestimated in view of the abundance of literature on EUC and IS/IT issues in small business. Findings from these studies could be used inductively to generate theory and hypotheses on EUC within the specificity of small business and the survey research used to explore and test the hypotheses before conducting an in-depth case study. On the basis of these arguments and after a thorough deliberation of the pros and cons of the various research strategies the second approach as suggested by Cavaye (1996) was adopted as being most appropriate to research. Three reasons were identified to justify the research strategy.

1. EUC is a relatively mature area within IS and from the survey of literature many of the existing propositions can be used inductively to form a first-cut theoretical model without using case study research in the first instance to derive the theory grounded by empirical data. Hence a deductive approach to survey research can be used in the first phase to test the model and explore its applicability within small business. In the second phase the revised model can be re-examined using case study research to test existing theory and build a richer and fuller context of the EUC phenomenon within the specificity of small business. Thus the second phase is not only to build new theory and propositions but also to test existing theory and propositions explored in the first phase. This is a valid and legitimate strategy as it enables the development and refinement of the EUC concepts, and confirmation of theory.
2. The main aim of the research is to gain an in-depth understanding of the EUC phenomenon within small business, which have been least understood and least

studied among IS issues (Raymond, 1990a). According to Yin (1989), case research is a good choice to study a new or rare phenomenon where theoretical knowledge is limited. This would enable a richer and fuller description of the phenomenon be undertaken that will contribute to the body of knowledge. The onus lies with the case research approach to meet this aim but a deductive survey approach would be beneficial to set the initial framework before an in-depth study is done. By doing so attention is focussed on a pre-determined number of variables whilst having the flexibility of discovering new variables as the research progresses.

3. Multiple research strategies combining survey and case study research will encourage the use of quantitative and qualitative methods of collecting data and analysing results. According to Cavaye (1996) both these methods can be used separately in any order or concurrently contributing to a fuller and richer picture surrounding the phenomenon. This will also enable cross-validation of results through triangulation and helps to explain unusual or diverging results. The order of a survey study (quantitative) followed by case study (qualitative) according to the author is particularly relevant when the quantitative analysis produced unusual or unexpected findings. This is especially true when a relatively mature area such as EUC is applied in an unknown situation such as small businesses creating a new phenomenon where previous findings may no longer hold. Hence survey research can be used to explore the newly applied concept and the findings can be used as part of a case study investigation to reaffirm previously held propositions and explain inconclusive evidence surrounding the phenomenon.

In light of the preceding justifications it is important to describe the main characteristics of the survey research and the case study research before detailed discussions of the actual methods are presented. The idea is to identify essential features of both methods and understand their strengths and weaknesses. As rightly put by Cavaye (1996) that the selection of a research strategy leads to a trade-off in which the strengths of one approach overcome the weaknesses in the other and vice-versa. It is hoped that by adopting both strategies the strengths of the overall research strategy could be maximised whilst at the same time overcoming some of the weaknesses.

The following are essential characteristics of survey research as described by Kraemer (1991) and Emory and Cooper (1991, p.318).

1. Survey research is designed to produce quantitative descriptions regarding a population which includes analysing relationships between variables and outcomes.
2. The main mode of data collection is through mail or interviews (personal or telephone) by asking structured, predefined questions. Responses are accepted for what they are and constitute the data to be analysed.
3. A sample that constitutes a fraction of the study population is used in a way that the findings can be generalised to the population.
4. Information can be gathered quickly and cheaply spanning a wide geographic area.

Some of the main characteristics of case study research as reported by Yin (1994) and Cavaye (1996) are as follows:

1. A case study research is an empirical inquiry designed to investigate a contemporary phenomenon within its real-life context especially when the evidence surrounding the phenomenon and its context is unclear and ambiguous.
2. Qualitative tools and techniques for data collection and analysis are mainly used though a quantitative approach is also possible.
3. Many sources of evidence for data collection are used including documents, archival records, interviews (often open-ended, semi or unstructured), direct observation, participant-observation, physical artifacts and less used sources such as films, photographs, videotapes, etc.
4. The phenomenon at one of a few sites (either single or multiple cases) is studied by investigating a pre-defined phenomenon with the aim to achieve an in-depth understanding of its context.
5. *A priori* constructs and relationships are not defined rather the aim is to contribute to knowledge by relating findings to generalisable theory.

Some of the main strengths and weaknesses of the survey research and case study research strategies are shown in Table 4.1 below. It should be reiterated that both research strategies are to be used as opposed to either one in order to gain maximum benefits from the study by capitalising on the strengths of both approaches at the same time minimising their weaknesses.

Table 4.1. Strengths and Weaknesses of Survey and Case Study Research Strategies

	Strengths	Weaknesses
Survey Research	▪ Findings can be generalised to a population ▪ Control over variables ▪ Can determine strength of relationship and direction of causation ▪ Tend to be more economical and efficient than observation	▪ Allow study of limited number of variables ▪ Information entirely depend on answers by respondents ▪ No direct real-life observation of the study phenomenon ▪ Poor response & low quality of information particularly in an area where very little is known
Case Study Research	▪ Capture real-life situation by studying a phenomenon in its natural context ▪ Allows the study of a large number of variables surrounding a phenomenon ▪ Able to develop and refine concepts for further study ▪ Provides added value to respondents by suggesting improvement (action-oriented)	▪ Cannot generalise findings statistically to a population ▪ No control over variables ▪ Cannot determine direction of causation ▪ Information overload with too many variables to observe

Looking at each of the approaches in turn within the context of the present study the survey research was chosen primarily for three main reasons. **Firstly**, to put the research into the right perspective by attempting to describe the nature and type of small businesses in relation to their IT adoption and EUC practice. This is achieved by choosing a sample that will represent small firms within the West Midlands area. A brief profile and demographic data of these firms will form part of the data to be gathered. The sample will be analysed to generate information on the state of IT adoption and EUC sophistication of small businesses in the participating area. Hence the findings should represent the IT and EUC situations of the general small business population.

The **second** reason was to use the empirical data to measure and determine IT and EUC sophistication and perform an initial exploratory analysis on factors that may be associated with IT and EUC sophistication. These factors have been identified inductively from related literature and form the basis of the first-cut initial model for

EUC sophistication in which hypotheses were formulated. Part of the analysis will test these hypotheses and to identify those factors that are statistically significant in their relationships with IT and EUC sophistication. Findings will be used to revise the initial model and this revised model is to be used as a research framework for the second phase case study investigation.

Finally the **third** reason for choosing the survey research was to identify small firms that are willing and interested to participate in the case study research. Ideally the selection of firms should be voluntary and those that can give cooperation and commitment throughout the duration of the research to ensure its successful completion. From a research point of view a good selection should be based on different combination of firms in the context of IT and EUC sophistication. This is in keeping with Yin's suggestion of literal replication for similar in-context analysis and theoretical replication for different in-context analysis (Yin, 1994).

Cavaye (1996) and Remenyi and Williams (1996) have suggested that the multi-faceted nature of IS makes case study an appropriate research strategy. Furthermore, studying contemporary events in their natural settings is more appropriate in a qualitative research method where case study research has emerged as a suitable candidate (Yin 1994; Mason 1996). Since EUC is multi-faceted and much of its theory untested and unexplored, employing the case study method is an appropriate strategy and justified for this research.

Apart from the multi-faceted nature of information systems, IS planning and development methodologies have emphasised the importance of understanding the business domain. One important aspect of case study research is its explanatory power (Yin, 1994) where interpretation of the phenomenon is essential in order to understand the complexity of real-life situation (Vidgen and Braa 1995; 1997). It is also an equally important outcome in IS methodologies to affect changes within the domain, and IS researchers have already begun to adopt an action-oriented strategy playing the role as participant-observer via the process of intervention (Ngwenyama 1993; Vidgen and Braa 1997). Vidgen and Braa (1997) further suggest a *hybrid* approach known as *Action Case* as alternative method for IS research taking both the advantage of case study research and action research to understand complex situation as well as to create change. This approach within the case study research strategy is particularly relevant for this study as it also helps the participating firms to evaluate their current EUC practices in particular and IT strategy in general. The results of the study would assist them with better options and informed opinions of the changes that are required. In addition this approach could also address the poor response issue in the survey approach that could not be resolved by the 'normal' case study approach.

According to Vidgen and Braa (1997) the two main characteristics of action case are:

1. The scope of investigation is more restricted than ordinary case studies such that "small scale" interventions are made in contrast to the ordinary case studies but not as intense as the *pure* action research. The aim is to gain practical knowledge of IS use (in this case EUC practice) and achieve a rich understanding of the context (the small firms) in which changes takes place.
2. Timescale of the *action case* research is shorter than the ordinary action research and longitudinal case studies. Since *pure* action research require intervention to achieve *significant* changes in the organisation, the time period would tend to be longer requiring more of the organisation's resources - time, people and probably finance. In small firms however these resources are not at their disposal but will be more tolerable if a shorter timescale is used with minimal disruption to the daily operation of the business.

Vidgen and Braa (1997) proposed four factors underlying the essential attributes of action case that provide support for such an approach to IS research. These factors and their justification to the research are discussed here. *Suitability* refers to the appropriateness of the action case method to the research in terms of research design and skills of the researcher. The action case method is considered appropriate to be incorporated within the case study in order to formulate an understanding of the EUC sophistication in small business. This is done by examining the factors influencing EUC sophistication and learning how EUC strategy can be formalised within the context of small business.

The next factor is *Interpretation*, which refers to the depth of understanding of the phenomenon and its context in terms of richness of scope and focus. To ensure richness within the context of small business, the scope of the project is considered wide enough to cover the organisation as a unit of analysis with participants represents all functional and managerial levels. The focus of the research is to cover a specific IS issue, namely EUC within the specificity of small business.

The third factor underlying the essential attributes of action case is *Intervention*, which is the timescale of the fieldwork, participation and commitment from organisations to the research, and criticality of the research to the business. The timescale for the fieldwork was estimated to be 3 months for one firm. Martin (1986a, p. 79) suggests timescales of between 3 to 6 months as reasonable for a small to medium-sized enterprise. The fieldwork will involve employing several fact-finding techniques that include interviews and field-notes with each interview recorded and transcribed onto text. Interview transcripts will then be sent for reviews to the participants for validation and amendment. Walk-throughs will then be carried out to verify the enterprise model that essentially consists of the data and process models. In terms of the level of participation, the characteristics of small business such as limited personnel resources and time constraints have made participation and long-term commitment to the research project difficult to achieve. To resolve this it was very important to get the cooperation and commitment from the company's CEO before the actual fieldwork begun. A scheduled action plan should be agreed and distributed to participants with messages describing the aims of the project and what is expected of the interview. In order to encourage positive cooperation and commitment each firm will be given an IT Research Report in the form of an IS strategy document upon successful completion of the project. In terms of the critical impact of the research to the business, no critical intervention is required that will drastically change the way IS is used in the participating firms. However, it was envisaged that the small scale intervention of the research in the form of ad-hoc suggestions and the EUC/IS strategy implementation was expected to have long-term effect in the form of changes to end-user development methodology, IS management and IT adoption.

The fourth factor characterising action case that provides support for IS research is *Practicability*. This refers to the organisational constraints such as economics of the research, access to participants, organisation politics, and control of the research that may hinder the progress of the research. Since the project deals with several participants it is essential that a contact person for each firm be identified in order to facilitate access. In terms of organisation politics, the project is not perceived to be politically sensitive from the small firm perspective. Since the sponsor will be the CEO himself, access will always be negotiated top-down. In terms of control, much of the fieldwork will involve activities outside the control of the researcher particularly participant's availability, mood and willingness to be interviewed, contact person's choice and the autocratic style of leadership making it more difficult to get "honest" views. However, the research focus, scope and scale has reduced the complexity such that control can still be achieved through the research framework, and the immediate benefits of the research to the firm should encourage positive motivation to the project and sustain the momentum for completion.

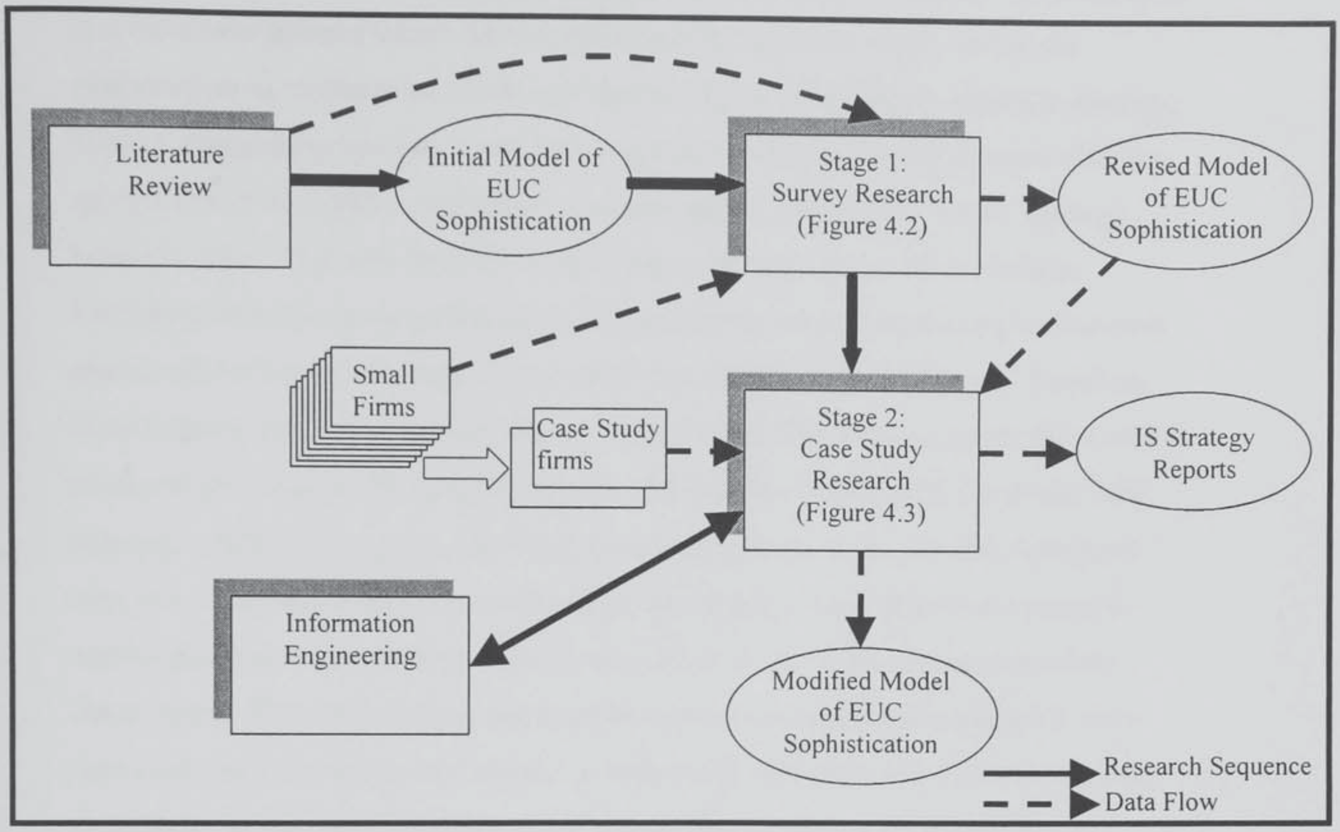
Apart from the justifications of the case study method discussed earlier, the factors and characteristics of action case identified by Vidgen and Braa (1997) above were also considered relevant to the EUC research and together they are used as reasons for choosing the case study research strategy.

4.3. OVERVIEW OF THE RESEARCH

The overall framework for conducting the research is presented in Figure 4.1. As has been discussed in the preceding section the research was to be carried out in two main stages involving a survey research in the first stage and an action case study research in the second stage. The research started with an extensive critical examination of published articles on EUC and prior research contributions on IT adoption and IS success in small business. As previously noted a total of more than seventy articles were reviewed from well over twenty refereed IS journals spanning a fifteen-year period. The list of journals and the number of articles cited along with the related areas covered by the articles are summarised in Table 3.1.

Following the research sequence of Figure 4.1, after review of the related literature, the initial model of EUC Sophistication presented in section 3.7 was developed. The model therefore has been developed inductively based on existing studies in IS/IT adoption and EUC studies in both large and small businesses. This approach is considered acceptable given the multi-disciplinary nature of IS research and the difficulty of synthesising theories from a number of different fields (Lucas, 1991). Details of the model and descriptions of its components were discussed in section 3.7.

Figure 4.1. The Overall Research Framework



Next the survey research will be conducted to elicit information on the level of IT adoption and EUC activities of small firms in the West Midlands area. The survey methods employed will include the construction of the questionnaire instrument based on information gathered from the related studies. A fieldwork and a pilot study of a few small firms will be conducted prior to the actual survey to test and validate the questionnaire. A mail survey will be carried out which includes monitoring and administering survey responses and data entry. The data from the survey will then be analysed using descriptive statistics and performing tests of hypotheses. The data will also be used to formulate measurements for IT sophistication and EUC sophistication indexes where correlation tests will be conducted on the hypothesised relationships that will produce the Revised Model of EUC sophistication following the data flow of Figure 4.1.

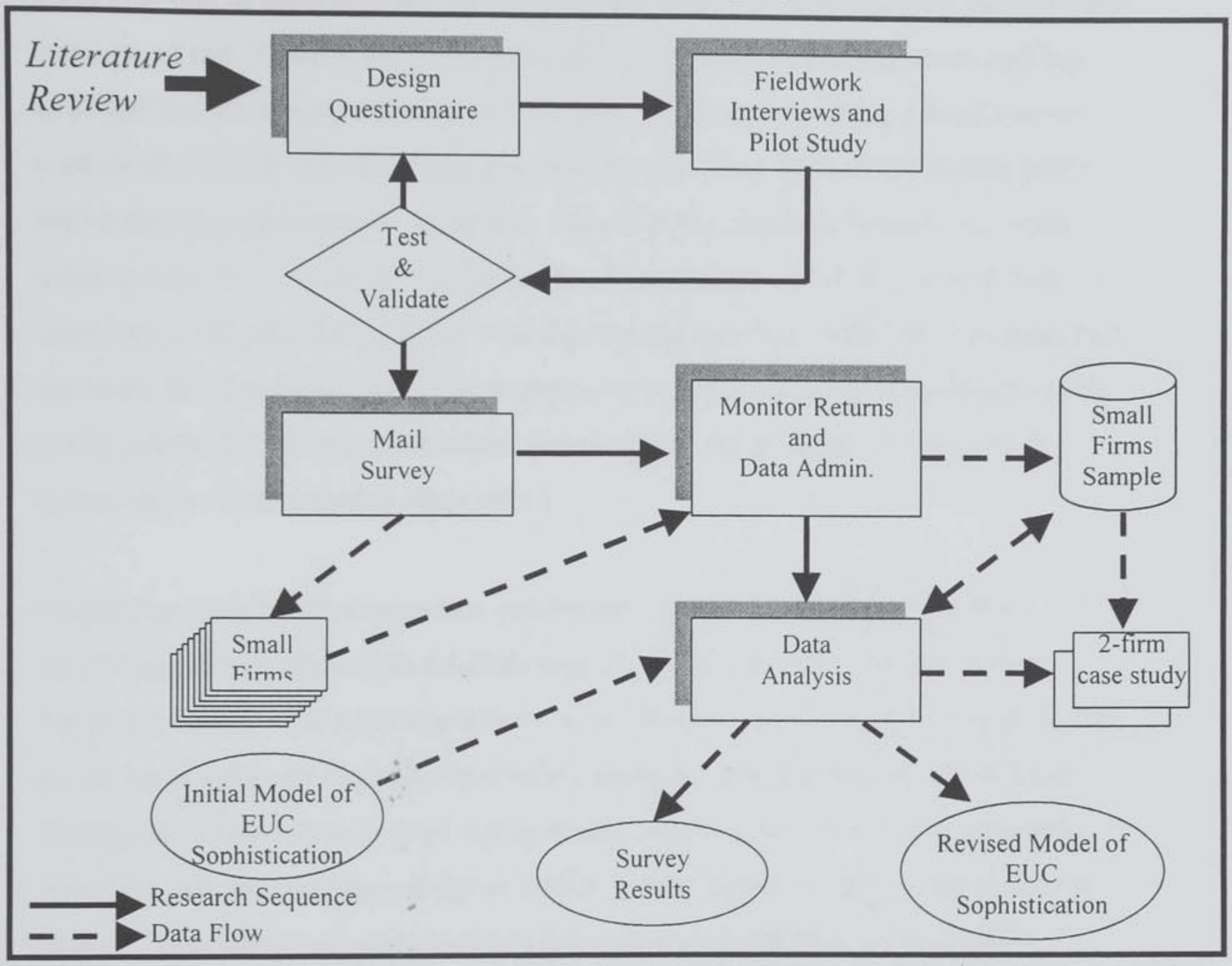
The Revised Model will then be used as the basis to guide the case study research in stage 2. Two or three firms will be chosen among those respondents who indicated their interest to participate in the case study investigation. Fact-finding and data gathering will be conducted using a well established IS strategy planning and development approach known as *Information Engineering*. This approach progresses in a top-down manner where the enterprise and its business requirements are examined so as to create an IS strategy that is aligned to the firm's business strategy. Since it was anticipated that small firms typically lacked a formal business plan the approach will be slightly modified to incorporate the study of the firm's strategic business plan. This will be done by studying the firm in terms of its business functions, identifying each functional area requirements and examining its business goals, critical success factors, critical decisions, and information needs. Based on these requirements the firm's IS strategy will be formulated and a report will then be produced and send to the respective firms. Meanwhile as the study progresses the enterprise data will be synthesised based on components in the revised model and kept in a comprehensive research database containing combinations of interview transcripts, fieldnotes, review notes, forms, direct observation and participation-observation. This information will then be used in the individual cases and cross-case analyses for patterns of evidence to support the propositions and relationships established in the revised model. New and additional variables emerged in the analyses will be identified and adjustments will be made to the Revised Model to produce the Modified Model of EUC Sophistication following the data flow of Figure 4.1.

The description of the survey research is summarised in the Survey Research Framework of Figure 4.2 and the Case Study Research Framework is shown in Figure 4.3. Detailed discussions of the Survey method will be presented in the next section and the case study research method will be discussed in section 4.5.

4.4. THE SURVEY (Stage 1)

The survey methods represented in the framework of Figure 4.2 below started with the design of the questionnaire where information sought were based on related literature as has been discussed previously. The questionnaire is divided into 3 main parts with a total of 24 questions where certain questions contain multiple item response. Part 1 of the questionnaire captures basic information regarding the profile and demographic data of the small firm. Part 2 deals with information on IT adoption which includes IT products and other technology-driven products, systems software and applications software. Information on EUC activities constitutes the third part of the questionnaire.

Figure 4.2. The Survey Research Framework (Stage 1)



The questionnaire was first pre-tested for content and structure with two groups of PhD students from the Computer Science Department and Aston Business School, Aston University. Minor changes and modifications were made based on the feedback received. A pilot study was then conducted on three small firms in the City of Birmingham where the questionnaire was subjected to another round of tests. Interviews were conducted with the three firms where the questionnaires were given to the respondents to fill in. One firm was represented by the CEO, another by a Director, and the third by the firm's Financial Controller. Two of the firms responded immediately to the questionnaire while the other retained the questionnaire and asked to come back the following day. The task of completing the questionnaire was timed and it took about 15 minutes on the average to complete a questionnaire.

One of the aims of the survey is to get as much response as possible by setting an initial target of 100 firms. Being aware of the reputation of small firms to have poor response rate, the questionnaire was designed to be short, precise and easy to fill in. Time was one of the major factors that encouraged good response apart from interest and ease of use. Overall the three firms were satisfied with the questions and they believed that the questionnaire meets the aims of the survey. They were however concerned with the few abbreviations that were used (eg. DSS, CAD/CAM, DTP) which they thought were too technical. However the rationale behind this is that users of such systems would recognise the abbreviations and if they do not then chances are they don't have them. Another reason was to do with the spacing so that the items in the questionnaire do not appear to be cluttered. A final adjustment was made and the 112-item questionnaire was then sent for printing. A copy of the questionnaire is enclosed in Appendix 1.

Studies have shown that responses of between 10%-20% are not uncommon involving surveys of small firms (Palvia et al., 1994; Lai, 1994; Raymond and Bergeron, 1992). The poor response by small firms to surveys was also highlighted by the local Business Link who has wide experience dealing with small business. Taking these views into account a pessimistic response rate of 10% was assumed. Based on this and the targeted figure of 100, a total figure of 1000 small firms was chosen. The addresses were randomly selected from a database of businesses registered for VAT maintained by the Birmingham Chamber of Commerce and Industry (BCCI). According to a BCCI source there were about 26,000 small firms in Birmingham and surrounding areas that are included in the database. However after examining the address list twenty records were discarded mostly due to duplicates and few firms were identified as branches of banks, government departments and other large organisations. The remaining 980 questionnaires were sent together with a freepost self-address return envelop to further encourage responses. The questionnaire was sent with a covering letter explaining the study and was addressed to the CEO whose name appears in the BCCI database. The CEO was asked to either complete the questionnaire him/herself or direct it to the person responsible for the administration of IT or the main user of IT, irrespective of whether the firm has a computer or not.

Since the Unit of Analysis is the firm itself, it was thought that the best strategy to get accurate information regarding the firm was to direct the questionnaire to the CEO. The CEO should be the right person to respond as he/she knows the firm well and should have the knowledge on the firm's IT adoption and EUC practice. This is particularly true in a small business environment where the CEO or entrepreneur who creates the business tends to dominate the functioning of the business which may include the IT function. Moreover according to Palvia and Palvia (1999) because of the small-business limited resources, the small business owner/manager is also the principal user of IT and often has to perform other IT functions such as computer operations, analysis, programming, IT acquisitions, etc. It was on this basis that the CEO or the person who met the criteria stated in the questionnaire was asked to respond. Though the response does not necessarily reflect the views of all staff members it should provide the necessary information to meet the aims of the survey.

A dateline of three weeks was given and one week before the dateline a follow-up mailing with a reminder letter was sent to those firms which had not responded to the first mailing. 150 firms responded to the first mailing and a further 72 responded to the second mailing bringing the total to 222 responses. It was decided that a further reminder was no longer required since the responses were considered overwhelming and far exceeded the target. A close check on each returned questionnaire revealed 36 questionnaires were deemed unusable with a number of the firms exceeded the 100 employees limit. Others include incomplete responses, firms located outside the catchment area, and those that have moved or ceased to operate. This brings the final figure to 186 firms with a response rate of 23.5%. The mailing exercise that included monitoring of returns and data administration was completed in just over 4 weeks.

Data entry was carried out using SPSS within which a database of the returns was created. Additional variables were added on multiple item questions and combinations of more than one question appearing in different parts of the questionnaire. These include 'totals' for the number of IT products, systems software, applications software, and number of user-developers. Variables are also created using combinations of items and questions such as End-User Typology using combinations of development tools, type of software and applications developed.

Both EUC Sophistication and IT Sophistication indexes are based on pre-defined application mean scores where the indexes were re-calibrated using additional items and variables. A step-wise regression analysis was done to determine the adjusted scores and formulate the re-calibrated measurement indexes.

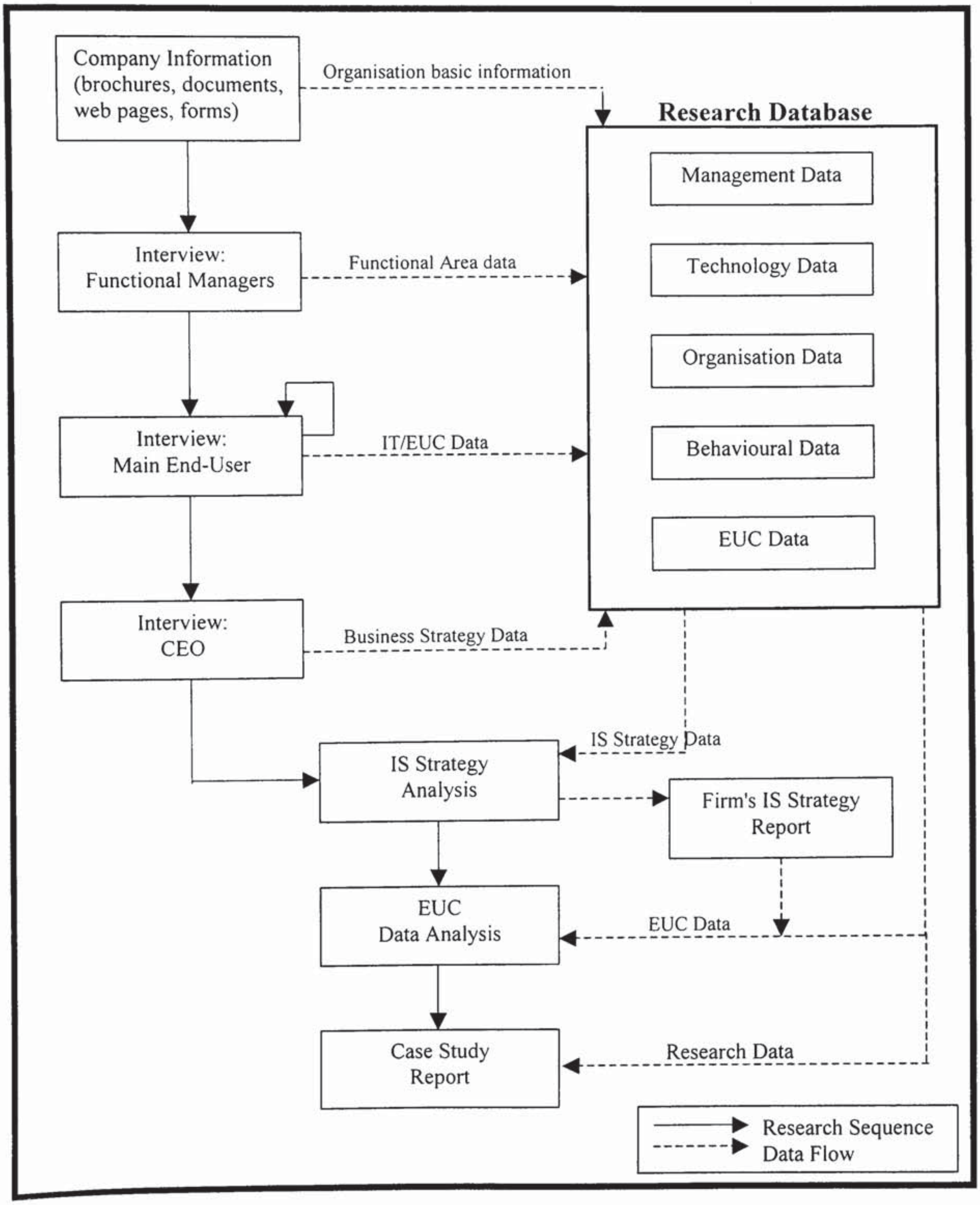
Data analysis was then carried out in 2 parts with the first part forming descriptive statistics of the small firms demography, IT adoption and the presence of EUC. Part 2 of the analysis involved tests of hypotheses using correlation analysis based on the Initial Model of EUC sophistication. Preliminary results of the survey were produced (Dahalin and Golder, 1998a) and copies of the survey reports were sent to those firms who indicated their interest. A copy of the report is included in Appendix 2. Significant relationships between the variables were identified and the model was revised accordingly to reflect the changes. Results of the survey are discussed in Chapter 5. With the formulation of the sophistication indexes firms interested to participate in the case study were identified from the sample database representing the different levels of IT and EUC sophistication. Stage 2 was then ready to be launched.

4.5. THE CASE STUDY (Stage 2)

Before stage 2 commenced criteria were set to choose the firms that can provide the necessary information to support the literal and theoretical replications discussed earlier in section 4.1. An in-depth understanding of the EUC phenomenon in small firms can be better achieved by studying firms with different levels of EUC sophistication with respect to IT sophistication. The different combinations can produce four sets of firms, those that have high level of EUC sophistication and those having low level of EUC sophistication, with high and low IT sophistication combination. A range of 2 to 4 firms is considered sufficient for an in-depth investigation in an action-oriented case study that would require 3-4 months each to complete. However it could not be denied that the more firms studied the better the analysis and more consistent the outcome will be. Given the limited resources and time constraint the findings based on 2 to 4 firms could still be significant especially when the evidence are consistent with the theoretical conjectures that were formulated in the form of hypotheses and propositions supported in stage 1 of the study.

The overall method for conducting the case study is presented in Figure 4.3. The case study method started with the design of different sets of questionnaires to capture information regarding the firms' business functions, company strategies, EUC sophistication, and IT inventories. The firms' profiles and other basic information were taken from the company brochures, documents, web pages and other forms.

Figure 4.3. The Case Study Research Framework (Stage 2)



A semi-structured, open-ended questionnaire was designed for interviews with the CEOs on the business strategy, and another set of questionnaire was designed for interviews with the managers to capture data on the functional area requirements. An EUC Sophistication questionnaire was used to gather information on the main end-user profile, task characteristics and types of applications developed. For IT inventory a form was created and the information completed by the respective firms. Samples of the questionnaires and form are included in Appendix 3. The information was then sorted under the various categories of Management, Technology, Organisation, Behavioural, and EUC based on the revised model of EUC sophistication. These categories constitute the research database as presented in Figure 4.3.

From analysis of the firm's IS strategy, an IS Strategy report was produced for each firm to mark the end of the firm's participation to the research project. A copy of each report is included in Appendix 4 and Appendix 5. Meanwhile further analysis was carried out to analyse information on EUC activities and using the research database to examine individual cases leading to a cross-case analysis for matching patterns of evidence. A report of the case study investigation of the firms forms part of this thesis and is included in Chapter 6.

4.6. RESEARCH HYPOTHESES

Based on the Initial Model of EUC Sophistication discussed in the previous chapter and shown in Figure 3.12 various factors have been identified to potentially influence EUC Sophistication in small business. The Initial Model incorporates Top Management Support, Technology Adoption, Organisational Characteristics and Behavior towards EUC as factors contributing to EUC sophistication. To support these relationships, hypotheses were formulated to test the underlying independent variables that constitute these factors against the dependent variables that make up the EUC sophistication construct. Six main research hypotheses have been formulated in which 4 hypotheses are related to the factors to be explored and 2 other hypotheses associating IT Sophistication with EUC Sophistication and EUC Sophistication with EUC Satisfaction.

Hypothesis 1: Top Management Support of EUC influences the level of EUC sophistication and the presence of EUC in small firms.

Top management support has been crucial in ensuring the success of IS development. Studies have shown that the more involved the top management in an IS project, the higher the chance of the project to be completed successfully. This is even true in small business where the CEO in particular plays a dominant role in all aspects of the business. Thong et al. (1996) found that CEO support and involvement in IS projects could affect IT adoption of small businesses. In addition, there is also evidence to suggest that CEO qualification is another important factor affecting the use of IT, particularly in very small businesses (Palvia et al. 1994). Thus the first hypothesis supports these arguments as follows:

H_{11}: The greater the CEO support, the higher the level of EUC sophistication of the firm.

H_{12}: The higher the CEO qualification, the higher the level of EUC sophistication of the firm.

H_{13}: The greater the CEO interest in EUC, the greater the chance that EUC will be present.

Hypothesis 2: Organisational characteristics determine the levels of EUC sophistication and IT sophistication of the small firms.

Review of the related literature showed that organisational characteristics are important in determining the effectiveness of EUC in an organisation, whether large or small. Brancheau and Brown (1993) identified organisational characteristics as one of the main components for effective management of EUC. This includes the location of firms whether situated in urban or rural area, which may affect access to support infrastructure. Raymond (1987) argued that both organisational characteristics and IS context influence the presence of EUC in small business. Thus organisational characteristics such as size, in terms of the number of employees and sales are used as variables that contribute to the presence of EUC in small business. In addition, the age of the business is also an influencing factor for computing in very small businesses (Palvia et al. 1994). Based on these arguments, 8 hypotheses have been formulated as follows:

H_{21}: Location of firms affects the levels of EUC sophistication.

H_{22}: Location of firms affects the levels of IT sophistication.

H_{23}: Firms with more employees tend to have higher levels of EUC sophistication.

H_{24}: Firms with more employees tend to have higher levels of IT sophistication.

H_{25}: Firms with higher sales turnover tend to have higher levels of EUC sophistication.

H_{26}: Firms with higher sales turnover tend to have higher levels of IT sophistication.

H_{27}: The more established the firm the higher its level of EUC sophistication.

H_{28}: The more established the firm the higher its level of IT sophistication.

Hypothesis 3: Technology adoption contributes to the levels of EUC sophistication and IT sophistication of the small firms.

As suggested by Raymond(1987), IS context is an influencing factor in determining whether small firms will engage in EUC. Among the variables identified to be significant are the number of applications in use and the level of hardware investment. This finding is also supported by other studies, among those, Amoroso and Cheney (1992) and later Lai (1994) on IT experience, Kagan et al. (1990) on the number of PCs and networking facilities, Magal and Lewis (1995) and Palvia et al. (1994) on systems and applications usage. Though most of these studies did not specifically examined the impact these variables have on the levels of IT sophistication and EUC sophistication, nevertheless these variables have been used as technology adoption factors to determine IT adoption, IS success and EUC success and/or adoption. From these observations, 3 dominating factors have emerged, namely *systems*, *technology*, and *applications* as described previously. A fourth factor, the firm's planned acquisition of IT products may also be an indicator of IT sophistication and EUC sophistication. The third hypothesis can now be further divided into 8 separate hypotheses as follows:

H_{31}: The greater the number of *systems* the higher the levels of EUC sophistication.

H_{32}: The greater the number of *systems* the higher the levels of IT sophistication.

H_{33}: The greater the use/range of *technology* the higher the levels of EUC sophistication.

H_{34}: The greater the use/range of *technology* the higher the levels of IT sophistication.

H_{35}: The greater the number of *applications* in use the higher the levels of EUC sophistication.

H_{36}: The greater the number of *applications* in use the higher the levels of IT sophistication.

H_{37}: The lesser the number of IT products planned to be acquired (*IT Plan*) the higher the levels of EUC sophistication.

H_{38}: The lesser the number of IT products planned to be acquired (*IT Plan*) the higher the levels of IT sophistication.

Notice that *IT plan* may be inversely related to both IT Sophistication and EUC sophistication. It may be argued that firms with significantly less technology sophistication tend to have less technology adoption, therefore these firms will have more opportunity to increase the number of IT products by increasing their investment in the technology. Conversely, as firms become more sophisticated in their adoption of technology, more systems and other IT products tend to be put in place. Hence the opportunity to acquire more IT products will become less compared to the less sophisticated adopters. However this does not imply that further acquisition of IT will stop or become insignificant in more sophisticated adopters.

Hypothesis 4: Behaviour towards EUC influences the level of EUC sophistication, EUC presence and EUC satisfaction in the small firms.

Behaviour towards EUC in particular and IT in general has appeared in a number of studies. User attitude for instance has been seen as an important factor influencing IT adoption and the presence of EUC. According to Winter et al. (1998), users' attitudes towards computers can predict computer use provided they are given the freedom of choice and knowledge about their computers. Rivard and Huff (1988) found a significant relationship exists between user attitude and end user development satisfaction. This is also supported by Amoroso and Cheney (1992) who found that user's attitudes towards end-user development is related to the levels of end-user information satisfaction. There is also a natural tendency that the user's own interest in EUC may also have an impact on the levels of EUC sophistication in the small firms. Six hypotheses have been identified to describe the behavioural issues.

H_{41}: User attitude towards EUC influences the levels of EUC sophistication.
H_{42}: User attitude towards EUC influences the presence of EUC.
H_{43}: User attitude towards EUC influences EUC satisfaction.
H_{44}: User interest in EUC influences the levels of EUC sophistication.
H_{45}: User interest in EUC influences the presence of EUC.
H_{46}: User interest in EUC influences EUC satisfaction.

Hypothesis 5: IT sophistication is independent of EUC sophistication and EUC presence in the small firms.

Not much is known about the relationship between IT sophistication and EUC sophistication and this study provides an initial attempt to explore this relationship. The concept of working smarter, not harder, may apply to EUC and IT in that end-user development may reduce the need for IT sophistication by more closely meeting business needs than acquiring more hardware or standard software.

The initial reaction in explaining this relationship was as firms get more sophisticated in their use of IT, their level of EUC sophistication may vary with some on the increase whilst others may remain low. This is because IT intensive firms tend to have better technical support, both within and outside the firm, that would help encourage EUC activities. On the other hand, IT intensive firms may already have *systems*, *technology* and *application* in place and they may no longer need end-user development.

Similarly, IT sophistication may or may not affect the presence of EUC. To help understand this relationship, 2 null hypotheses have been formulated:

H_{51}: There is no evidence to support the existence of a significant relationship between IT sophistication and EUC Sophistication in small firms.
H_{52}: There is no evidence to support the existence of a significant relationship between IT sophistication and the presence of EUC in small firms.

Hypothesis 6: EUC sophistication is related to EUC satisfaction.
Though EUC satisfaction has not been studied in relation to EUC sophistication, EUC success, often used as surrogate measure of satisfaction in the past (Doll and Torkzadeh 1988), has appeared to be affected by EUC sophistication in small firms (Zinatelli et al., 1996).

H_{61}: Small firms with high level of EUC sophistication tend to be more satisfied with their EUC.

These hypotheses will then be tested using correlation analysis and significant relationships will be identified and matched against the Initial Model. The hypotheses are based on operationalisation of the research variables discussed in the next section.

4.7. OPERATIONALISATION OF THE RESEARCH VARIABLES

Table 4.2 presents the operationalisation of the research hypotheses that links the individual hypothesis defined in the preceding section with the measurements used to associate the independent and dependent variables. The measures are based on items appeared in the questionnaire where their corresponding links are shown in Table 4.3 below. The measures used in this study have been used in previous studies and where appropriate have been adapted to suit the small business context. Measures adapted from previous studies have been used mainly because of the absence of such measurement constructs within studies of EUC in Small Business. The exception is EUC Satisfaction, where as previously noted in section 3.4.3, instruments have been developed to measure end-user satisfaction with their IS as in Palvia (1996), Doll and Torkzadeh (1988) and others. Whilst this may give a better and accurate result, the intention is not to study EUC Satisfaction, but to study its relation with EUC Sophistication. An alternative but short and simpler one-item Overall Satisfaction measure has been used in Thong et al. (1996) to measure IS Effectiveness. Zinatelli et al. (1996) used a one-item Perceived Impact to measure EUC Satisfaction. The one-item Overall EUC Satisfaction measure was used in this study in keeping with the aim to keep the questionnaire short and simple in order to encourage better response.

Table 4.2 Operationalisation of the Research Hypothesis

Hypothesis	Measurements	
	Independent Variables	**Dependent Variables**
Hypothesis 1:Top Management Support influences EUC Sophistication and EUC Presence.		
▪ H_{11}: CEO Support affects EUC Sophistication	CEO Interest (support) in EUC	EUC Sophistication Index
▪ H_{12}: CEO Qualification affects EUC Sophistication	CEO Qualification	EUC Sophistication Index
▪ H_{13}: CEO Interest contributes to EUC Presence	CEO Interest (support) in EUC	EUC Presence
Hypothesis 2: Organisational Characteristics determine EUC Sophistication and IT Sophistication.		
▪ H_{21}: Location affects EUC Sophistication	Location	EUC Sophistication Index
▪ H_{22}: Location affects IT Sophistication	Location	IT Sophistication Index
▪ H_{23}: Employee Size affects EUC Sophistication	Size of Firm	EUC Sophistication Index
▪ H_{24}: Employee Size affects IT Sophistication	Size of Firm	IT Sophistication Index
▪ H_{25}: Sales Turnover affects EUC Sophistication	Sales Turnover	EUC Sophistication Index
▪ H_{26}: Sales Turnover affects IT Sophistication	Sales Turnover	IT Sophistication Index
▪ H_{27}: Firm Age affects EUC Sophistication	Age of Business	EUC Sophistication Index
▪ H_{28}: Firm Age affects IT Sophistication	Age of Business	IT Sophistication Index
Hypothesis 3: Technology Adoption affects EUC Sophistication and IT Sophistication		
▪ H_{31}: Systems affects EUC Sophistication	No. of Systems in use	EUC Sophistication Index
▪ H_{32}: Systems affects IT Sophistication	No. of Systems in use	IT Sophistication Index
▪ H_{33}: Technology affects EUC Sophistication	No. of Technology Products used	EUC Sophistication Index
▪ H_{34}: Technology affects IT Sophistication	No. of Technology Products used	IT Sophistication Index
▪ H_{35}: Applications affects EUC Sophistication	No. of Applications computerised	EUC Sophistication Index
▪ H_{36}: Applications affects IT Sophistication	No. of Applications computerised	IT Sophistication Index
▪ H_{37}: IT Plan inversely related to EUC Sophistication	No. of IT Product planned	EUC Sophistication Index
▪ H_{38}: IT Plan inversely related to IT Sophistication	No. of IT Product planned	IT Sophistication Index
Hypothesis 4: Behavior towards EUC affects EUC Sophistication, EUC Presence and EUC Satisfaction.		
▪ H_{41}: User Attitude influences EUC Sophistication	Attitude towards EUC	EUC Sophistication Index
▪ H_{42}: User Attitude influences Presence of EUC	Attitude towards EUC	EUC Presence
▪ H_{43}: User Attitude influences EUC Satisfaction	Attitude towards EUC	EUC Satisfaction
▪ H_{44}: User Interest influences EUC Sophistication	Interest in EUC	EUC Sophistication Index
▪ H_{45}: User Interest influences EUC Presence	Interest in EUC	EUC Presence
▪ H_{46}: User Interest influences EUC Satisfaction	Interest in EUC	EUC Satisfaction

Continue Table 4.2 Operationalisation of the Research Hypothesis

Hypothesis 5: IT Sophistication is independent of EUC Sophistication and EUC Presence.		
▪ H_{51}: No significant relationship between IT Sophistication and EUC Sophistication	IT Sophistication Index	EUC Sophistication Index
▪ H_{52}: No significant relationship between IT Sophistication and EUC Presence	IT Sophistication Index	EUC Presence
Hypothesis 6: EUC Sophistication affects EUC Satisfaction.		
▪ H_{61}: EUC Sophistication affects EUC Satisfaction	EUC Sophistication Index	EUC Satisfaction

Whilst Table 4.2 shows the measurements used to test the individual hypothesis, Table 4.3 identifies the measures used to operationalise the research variables. Certain measures are based on single item question while others are based on multiple item questions and combinations of different questions. Some of the questions are taken directly from the questionnaire while others require further computation and scrutiny of related information. One example is "Q21. Usefulness of EUC (reasons)" where instead of using the "Yes" or "No" answer, close examination of the reasons given by the respondents were done to determine the "Attitude towards EUC" measure. In this case a scale was constructed to rate the attitude of the respondent, from negative (ie. "No") to most positive, depending on the reasons given. A more complicated measurements for IT sophistication and EUC sophistication made use of the item values in the related questions to compute the sophistication index. Re-calibrated sophistication constructs introduced in section 3.5 were developed using data from the related questions to predict sophistication scores originally developed by Kagan et al. (1990) discussed in section 2.5.

Table 4.3. Operationalisation of the research variables.

Variables	Measure	Scale	Question
Top Management Support	1. CEO Interest (Support) in EUC	Nominal (adapted from Thong et al. 1996)	Q3. Job Title of respondent Q23.Interest to be involved in EUC study
	2. CEO Qualification	Ordinal (Palvia et al. 1994)	Q4. CEO's Qualification
Organisational Characteristics	1. Location	Nominal (Palvia & Palvia, 1999)	Q1. Company Address (postcode)
	2. Size of Firm	Ratio (Raymond, 1987)	Q8. No. of Staff
	3. Age of Business	Ratio (Raymond, 1987)	Q2. Date Established
	4. Sales Turnover	Ratio (Raymond, 1987)	Q9. Annual Sales
Technology Adoption	1. No. of *Systems* in use 2. No. of *Technology* products used	Ratio (Adapted from Brancheau & Brown, 1993; Aggarwal, 1994,	Q16.IT Product count Q15.Technology Product count

	3. No. of *Applications* computerised 4. No. of IT products planned to acquire	Raymond, 1987)	Q17.Computerised Application count Q16.IT Product plan count
Behavior Towards EUC	1. Attitude towards EUC 2. Interest in EUC	Ordinal (Adapted from Rivard &Huff, 1988 and Nominal Igbaria, 1990)	Q21.Usefulness of EUC (reasons) Q23.Interest to be involved in EUC study
EUC Presence	1. EUC Presence	Nominal (Raymond, 1987)	Q18.You/other staff developed application
EUC Sophistication	1. EUC Sophistication Index ▪ End-user Typology ▪ No. of users ▪ Application Sophistication	Ratio (Adapted from Blili et al. 1996; Kagan et al. 1990; Zinatelli et al. 1996)	Q20. Development Tool, Application, No. of User, Developer
EUC Satisfaction	1. Overall EUC Satisfaction	Interval (Adapted from Thong et al. 1996 and Zinatelli et al. 996)	Q19.Satisfied with applications
IT Sophistication	1. Software Sophistication Index	Ratio (Kagan et al. 1990)	Q15.Other IT Products Q16.IT Products Q17.Computerised/Other IT Activities

Table 4.3 presents the operationalisation of the variables discussed in this chapter with the measures and scales used in the questionnaire instrument. In the questionnaire instrument, Top Management Support for EUC is represented by 2 variables, CEO Interest (support) in EUC and CEO Qualification. CEO Interest is derived from Job Title of respondents representing the top management of the company (owner, chairman, CEO and managing director) who have indicated their interest to be involved in EUC investigation and their support for EUC practice. CEO qualification is an ordinal variable with a value of 1 indicating the lowest qualification to 5 indicating a higher degree qualification.

In the questionnaire instrument organisational characteristics are represented by 4 variables, namely location (urban or rural), size of the firm (number of employees), sales turnover and age of the business. With the exception of location, the other 3 variables are taken directly from the questionnaire. Location is derived from the postcode, which forms part of the firm's address. Postcodes within and surrounding the city centre of Birmingham (the second largest city in the UK) are classified as 'urban'. Others are classified as 'rural'.

Technology adoption is covered by the second part of the questionnaire, that is the Use of Information Technology. A list of 16 common IT products and systems software make up the *Systems* variable. This includes word processing systems, spreadsheet, and database and more specialised systems such as CAD/CAM, robotics and expert systems. *Technology* is classified as other IT products not within the computer category. Nine items have been identified which include facsimile, mobile phone, electronic organiser, PABX, video/tele-conferencing facility, etc.

A total of 18 items are used to identify typical small business activities in which computerised applications can be used. Respondents were asked to identify their business activities according to the following combinations:

- Manual activities
- Computerised activities
- Other IT activities
- Manual and Computerised activities
- Manual and Other IT activities
- Manual, Computerised and Other IT activities
- Computerised and Other IT activities

IT Plan is an indicator of the respondent's intention to acquire IT products and systems software. The same list of 16 items used for the *Systems* variable was employed. The lists of all the items for the *Systems*, *Technology*, *Applications* and *IT Plan* variables are shown in Appendix 6. In each case the variable is the count of the number of items in the corresponding list marked by the respondent.

Two variables are used in the questionnaire for Behavior towards EUC. *Attitude* towards EUC is used to gauge the respondent's opinion on whether it is useful for users to develop their own applications. The other variable, *Interest* in EUC is used to indicate the respondent's interest in the EUC project and the possibility of getting involved in such project.

Using the above measures relationships are tested for significance among the variables to identify factors affecting EUC Sophistication in Small Business.

Relationships with IT Sophistication, EUC Presence and EUC Satisfaction will also be tested as defined in the hypotheses guided by the Initial Model of EUC Sophistication in Small Business. Operationalisation of both EUC Sophistication and IT Sophistication variables (indexes) will be presented in the next chapter. The analysis of the survey results and the resulting Revised Model of EUC Sophistication in Small Business are also presented in the next chapter.

4.8. SUMMARY OF THE RESEARCH METHODS USED

Based on the Overall Research Framework of Figure 4.1, four major steps have been identified to complete the research process. First is the task of establishing sufficient theoretical conjectures to provide the foundation of the subject to research. This is accomplished by conducting a critical review of the related literature resulting in the formation of the Initial Model of EUC Sophistication in Small Business as presented in Figure 3.12. Next the mail survey of IT Adoption and EUC will be carried out where the Initial Model will be tested resulting in the Revised Model of EUC Sophistication. A framework for the survey is presented in Figure 4.2. This second step is also used to identify firms from the sample survey for the case study investigation.

The third major step will involve conducting action case studies on the selected firms using the Revised Model as a guideline. The investigation will use an IS methodology approach involving an IS strategy based on the Information Engineering method. A framework for the case study is presented in Figure 4.3.

The fourth and final step will involve analysing the case study information, performing cross-case analysis and consolidating the results with the survey results. A final deliverable will be produced in the form of a Modified Model of EUC Sophistication.

The next chapter will present the second major step of the research process, which is the analysis and results of the survey of IT adoption and EUC in small business.

CHAPTER 5. SURVEY OF INFORMATION TECHNOLOGY ADOPTION AND END-USER COMPUTING IN SMALL BUSINESS

5.0. INTRODUCTION TO THE SURVEY

This chapter describes the analysis and results of Stage 1 of the research, that is the survey of IT adoption and EUC in small business. As mentioned in the foregoing chapter the survey has resulted in a valid sample of 186 small firms in the West Midlands, United Kingdom, which was carried out in the months of November and December 1997. Descriptive statistics, cross tabulation, correlation analysis, Chi-square and regression analysis were employed as means of analysing the data to produce meaningful results. Statistics on the profile of the small firms are presented which give indications of the type of firms and nature of businesses represented by the sample of the small business population in the West Midlands. Statistical analysis was carried out on IT adoption and the presence of EUC to solicit information on the level of IT use and EUC activities within the population. Results of the analyses are presented using frequency counts, percentages and averages in the form of figures of tables.

A detailed discussion of the sophistication indexes for both EUC and IT sophistication is also presented. Appropriate literature had been sought to identify the dimensions that made up the sophistication constructs. Measurement of the constructs and formulation of the indexes are described and the operationalisation of the indexes presented. Hypotheses discussed in the preceding chapter are tested and results of the correlation analysis are presented. Adjustments are made to the Initial Model to produce a Revised Model of EUC Sophistication in Small Business.

5.1. ANALYSIS OF THE SURVEY RESULTS

The survey results are presented in 4 sections based on information in the questionnaire. The first section describes the firm's profile which includes the company's background information and respondent's profile. The second section analyses the firms' use of IT describing their IT experience, support staff, hardware, software and applications requirements. The third section examines the presence of EUC, looking at the tools and applications developed by end-users, user satisfaction with the applications, and usefulness of EUC to the firm. The final section is a cross-analysis of the data presented in the previous 3 sections, combining relevant information in the firm's profile, IT adoption and EUC. Tables and figures are presented to aid the analysis.

5.1.1. Analysis of the firm's profile

Tables 5.1 through 5.9 present the distribution of the firm's demography and background information. Since firm size is an important measure for small business the size distribution based on the number of full-time employee is used as shown in Table 5.1. The size band used was based on the EU classification as described previously, which are 1-9 as *micro* and 10-99 as *small*. However since the *small* range is too wide and contains more than 95% of the sample data, the range is further sub-classified into two. Hence the size band used in Table 5.1 has three categories: 'Small' *small* (micro) with 1-9 employees, 'Medium' *small* with 10-49 employees, and 'Large' *small* with 50-99 employees. It should be noted that a number of countries have also used the 50-employee limit as the small firm definition as discussed previously in Chapter 2. Hence the sub-classification between the 'Medium' and 'Large' *small* firms at the 50-employee level should be justified.

Table 5.1. Size Distribution of Sample Firms

Size Band (no. of employees)	Frequency	Percentage	Cum. Frequency	Cum. Percentage
Small *small* (1 - 9)	6	3.4	6	3.4
Medium *small* (10 - 49)	113	64.6	119	68.0
Large *small* (50 - 99)	56	32.0	175	100.0

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

Though a small percentage of the firms belong to the micro or 'Small' *small* category as suggested by the data in Table 5.1, the majority appears to be in the Medium *small* category with almost 65% of the sampled firms. The average firm size is calculated to be 43.5 employees as shown in Table 5.2 below and this may indicate that the sample firms represent typical small business situation.

Table 5.3 presents the profile of the firms in terms of the demography and background information. Part I of the table shows that more than half of the sampled firms belong to the 11-50 years age group. This indicates that the majority of the firms are relatively matured with more than 80% having been in business for at least

10 years. This is also evidence by the overall mean age of 41.8 years as summarised in Table 5.2 with a wide age distribution ranging from 1 year to 212 years. Interestingly analysis of the different age groups reveals the relatively mature firms tend to be firms with a larger number of employees. The mean age of the firm for the three size band categories is shown in Table 5.4. As can be seen the average age increases with the firm size with both averages for the 'medium' and 'large' categories exceeded the overall mean age.

Table 5.2. Summary of Sample Firms' Profile

Variables	N	Min.	Max.	Mean	Std. Dev.
Size (no. of employees)	175	3	99	43.46	23.15
Age of Firm (years)	174	1	212	41.78	42.65
Annual Sales (£ millions)	143	0.25	35	4.55	5.50

Table 5.3. Distribution of the Demography and Background Information of the sample firms

	Frequency	Percentage	Cum. Frequency	Cum. Percentage
I. By Age (Years)				
0 - 10	30	17.2	30	17.2
11 - 50	96	55.2	126	72.4
51 - 100	26	14.9	152	87.4
100+	22	12.6	174	100.0
II. By Location				
Birmingham City	106	57.0	106	57.0
Outer Birmingham	72	38.7	178	95.7
Other W. Midlands	8	4.3	186	100.0
III. By Sales (£ million)				
Below 1.0	14	9.8	14	9.8
1.0 - below 3.0	59	41.2	73	51.0
3.0 - below 5.0	29	20.3	102	71.3
5.0 - below 10.0	25	17.5	127	88.8
10.0 and above	16	11.2	143	100.0
IV. By Industry				
Agriculture	1	0.5		
Manufacturing	101	54.3		
Construction	24	12.9		
Wholesale & Retail	17	9.1		
Professional	22	11.8		
Services	21	11.3		
V. By Ownership				
Individual	2	1.1		
Partnership	17	9.3		
Family Business	22	12.0		
Private Limited	124	67.7		
Public Company	12	6.6		
Others & NGOs	6	3.3		

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

Table 5.4. Age of Firm by Size Band

Size Band (years)	Mean	N	Std. Dev.
1 - 9	25.20	5	20.24
10 - 49	42.62	108	44.79
50 - 99	43.35	51	41.09
Total	42.31	164	43.06

Part II of Table 5.3 shows the distribution of the firms by location with the majority of the sample (ie. 57%) located within the City of Birmingham. In addition, firms located within the city tend to be much older with a mean of 47.4 years compared to 30.4 years from those in the rural areas. Table 5.5 summarised the age distribution by location and size of the firms. In the urban area there is no significant difference between firms in the 'medium' and 'large' small categories whereas for firms located in the outskirts of the city the 'medium' category is much younger. Analysis was not done on the micro or 'small' category due to the very small sample size.

Table 5.5. Age Distribution by Location and Size of Firms

Size Band	Location	Mean	N	Std. Dev.
Small (1 - 9)	Rural	52.00	1	.
	Urban	18.50	4	15.71
	Total	25.20	5	20.24
Medium (10 - 49)	Rural	24.60	28	26.94
	Urban	48.92	80	48.10
	Total	42.62	108	44.79
Large (50 - 99)	Rural	37.40	20	35.90
	Urban	47.19	31	44.25
	Total	43.35	51	41.09
Total	Rural	30.38	49	31.11
	Urban	47.40	115	46.43
	Total	42.31	164	43.06

The distribution of the sample firm by Sales Turnover is shown in Part III of Table 5.3. Most of the firms registered annual sales ranging from £1 to £3 million in 41% of the sample. The next 20% came from the £3 to £5 million category. This is followed by the £5 to £10 million and above £10 million categories with 18% and 11% of the sample firm, respectively. The smallest remaining 10% of the sample registered below £1 million sales.

Sales figures have also been used as an alternative measurement for firm's size either individually or in conjunction with number of employees. However question have been raised on the reliability of the sales figure written on the questionnaire. Due to the confidentiality and sensitivity of performance-related questions, firms are reluctant to give a true picture of the sales or profit figures compared to the less sensitive information such as number of employees, age, location, ownership, etc. This is also reflected by the information presented in Table 5.3 where the Sales category has the highest number of "no response" with slightly more than 23% did not respond to the question.

Demographic distribution by industry clearly shows the Manufacturing sector in the lead, accounting for more than half of the sample as shown in Part IV of Table 5.3. This is not surprising considering that Birmingham and the West Midlands traditionally have been one of UK's manufacturing strongholds. This is followed by the Construction sector with almost 13% of the sample. Next is Professional Services (12%) that includes solicitors, data services, consultants, financial intermediaries, education and real estate. The Service sector accounts for 11% and includes the utilities, transportation, hotels and restaurants, health and social work, and other community and non-government organisations. Other sectors include Wholesale and Retail (9%) and Agriculture (0.5%). Only one firm in the sample represented the Agriculture sector, which is an irrigation company with 22 staff located outside Birmingham. Due to the small sample size further analysis is not done for the Agriculture sector.

Table 5.6. Firm Size by Industry

Industry	Mean	N	Std. Dev.
Agriculture	22.00	1	.
Manufacturing	44.03	93	24.28
Services	45.11	19	20.67
Construction	44.65	23	24.43
Wholesale & Retail	34.41	17	13.56
Professional Services	46.32	22	24.96
Total	43.46	175	23.15

Table 5.6 above shows the mean firm size based on the different sectors of the industry. On the average firms in the Services sector appear to employ the most number of staff with the Professional Services leading followed by the other Services sector. The least employed are firms in the Wholesale and Retail industry, while the Construction and Manufacturing sectors have approximately the same number of employees and stood closest to the overall average firm size.

In terms of ownership (Part V, Table 5.3), Private Limited companies dominate the sample data with nearly 68% of all firms. A far second is Family Business with 12% of the sample size. This is followed by Partnership (9%), Public Companies (7%), Others and NGOs (3%), and only 2 firms (1%) are from individual entrepreneurs. In terms of age, Family Business has the highest mean age and this may indicate that this type of business tend to exist over longer period of time in successive generations passing from father to sons. Next are the Private Limited companies that traditionally tend to originate from family typed business as a result of sell-outs/buy-outs, mergers and acquisitions. The average age of Partnership-typed business is relatively lower and significantly less than the overall mean of 41.78 years. This is also true for Public Companies and other Non-Governmental Organisations (NGOs).

Table 5.7 below shows the distribution of the respondent's profile by Job category. Top executives made up the largest group of respondents with 54.2% of the sample. The middle management represented by the managerial and professional category made up almost 41% of the sample, and the remaining 5% came from the clerical or lower management group. It is interesting to note that based on these distribution responses to the survey represent opinions of end-users of IT mainly occupying the top-level management of the firm. The questionnaire explicitly stated that respondent should preferably be the person responsible for IT. The fact that only 5% of the respondents hold IT-related job title may indicate that the majority of the firms in the sample did not have a formal IT support function or IT professionals. This is consistent with the characteristics of small business mentioned earlier in Chapter 2.

Table 5.7. Distribution of the Respondent's Profile by Job Category

Job category	Title	Frequency	Percentage
CEO/Top Management	CEO/Chairman	4	2.2
	Managing Director	43	23.8
	Director	45	24.9
	Partner	6	3.3
Managerial/Professional	Manager	44	24.3
	Accountant	11	6.1
	Company Secretary	8	4.4
	QS/Chartered Surveyor	2	1.1
	IT Officer/Manager	9	5.0
Clerical/Lower Management	Secretary/Admin	8	4.4
	Clerk	1	0.5

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

In terms of CEO's qualification slightly more than half of the sample did not indicate any qualification. However out of the 46% who responded, more than three-quarter of the CEOs have at least a degree or professional qualification. The distribution of the CEO's qualification is shown in Table 5.8 below. It is also interesting to note that many of the top management respondents themselves did not indicate their own qualification as shown in Table 5.9. Also 80% of those who indicated having a Masters or PhD degree was the top management respondents themselves. Table 5.9 also indicates that all categories of CEO qualifications mostly came from the respondents themselves either because other staff are not aware of their CEO qualification or it could be a sensitive information particularly if the CEO possesses lower level of qualification as suggested by the high non-response rate.

Table 5.8. CEO Qualification Percentage Distribution

Qualification of CEO	Frequency	Percent	Cum. Percent
Diploma	9	4.8	4.8
Technical	10	5.4	10.2
Professional	23	12.4	22.6
Degree	38	20.4	43.0
Higher Degree	5	2.7	45.7
Total	186	54.3	100.0

Table 5.9. CEO Qualification by Job Category

	Job Category of Respondent			
Qualification of CEO	CEO/ Top Management	Managerial/ Professional	Clerical/ Lower Management	Total
Diploma	6	3		9
Technical	6	3		9
Professional	14	9		23
Degree	23	13	2	38
Higher Degree	4	1		5
Total	53	29	2	84

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

5.1.2. Analysis of the Firm's IT Adoption

This next section analyses the firm's use of information technology utilising Part II of the questionnaire instrument. A summary of the IT Adoption result is presented in Table 5.10. Overall firms in the sample are generally IT literate with an average of almost 10 years of using IT. In addition more than 80% of the responding firms reported using IT for more than 5 years. This is not surprising considering the mean age of the firms at around 42 years and well-established firms of that age today would tend to use IT. Despite the generally literate level of IT, the number of staff whose main function is to support IT appears to be minimal with a mean of 2.5 people as shown in Table 5.10. Over a quarter of the sample reported having no support staff at all. More than half of the sample firms employ up to 2 staff supporting IT. The fact that nearly 75% of the firms indicated having at least one member of staff supporting IT is seen to be a positive development for IT adoption within small business as small firms have been characterised as experiencing limited technical expertise.

In terms of using PCs all (N=182) of the sample firms who responded to the question used at least one PC with a mean of 13.8 PCs. However a closer look at the four non-responding firms reveals that all four firms indicated elsewhere in the questionnaire using PC software such as word processor and spreadsheet. On the basis of this information it could be deduced that all firms in the sample are using PCs. The maximum of 85 PCs as shown in the table belonged to a legal firm with equivalent number of end-users using the PCs individually.

Table 5.10. Summary of IT Adoption of the sample firm

Variables	N	Min.	Max.	Mean	Std. Dev.
Years using IT	170	1	20	9.6	4.6
Staff supporting IT	157	0	50	2.5	5.8
Number of PCs	182	1	85	13.8	15.1
Number of users	167	1	85	17.5	18.1
Total IT products used	185	3	8	4.9	1.1
Total Systems used	184	1	15	5.8	2.4
Total Systems planned	102	1	7	2.3	1.3
Total Computerised Applications	186	0	18	7.9	3.9

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

The proportion of firms using networking as part of their IT adoption is also significant. Seventy-percent of the firms use network to connect their computers and with an average of almost 14 PCs per firm networking would help facilitate communication and sharing of computer resources among the average 17.5 users within the firm. Moreover it is interesting to note from the sample data that firms tend to adopt a one-to-one user to PC ratio with a mode of 1.0 and a mean of 1.4. Whilst each user may have their own PCs, the data also suggests that not all staff are users of IT with one in six staff on the average has access to a PC. However almost 56% of the firms have at least 10 users of IT and together these information suggest that the sample firms are generally IT literate as earlier claimed.

Table 5.11 below summarised the respondents' responses on the remaining IT adoption variables. Surprisingly a significant number of firms indicated using minicomputers or mainframes with 45.6% of the sample. At a glance this may be true for generally matured and established firms with experience in IT as suggested by the sample firm. However a closer examination of the data showed that there is no difference between those who use mini's or mainframes with firm's age and those who use mini's or mainframes with IT experience. The former has a firm average of 41.9 years with mini's or mainframe and 41.2 years for those without mini's or mainframe. Similarly in terms of IT experience both has approximately the same mean, i.e. 9.9 years and 9.4 years, respectively. This may suggest that the firms who indicated using mini's or mainframes were not inheriting the legacy of the older generation minicomputers or mainframes that are still thought to belong exclusively to the large organisations. On the contrary those who responded with the affirmative may find a need to distinguish between a server and a PC, and therefore indicated servers as

Table 5.11. Summary Responses of IT Adoption variables

Variable	Frequency		Percentage	
Own a Mini or Mainframe	83		45.6	
Use External Computer Services	39		21.5	
Outsourcing	9		4.8	
Use Other IT Products				
1. Fax	186		100.0	
2. Telephone	183		98.4	
3. Mobile Phone	178		95.7	
4. Modem	156		83.9	
5. PABX	66		35.5	
6. Electronic Organiser	65		34.9	
7. Network hub,router	47		25.3	
8. Tele/Video Conferencing	12		6.5	
Use Systems Software	**Current**	**Plan**	**% Current**	**% Plan**
1. Word Processors	182	1	97.8	0.5
2. Spreadsheet	171	2	91.9	1.1
3. Database	151	11	81.2	5.9
4. Mail Merge	95	9	51.1	4.8
5. Internet	85	64	45.7	34.4
6. Electronic Mail	84	50	45.2	26.9
7. Graphics	80	7	43.0	3.8
8. CAD/CAM	60	20	32.3	10.8
9. Desk-Top Publishing	53	5	28.5	2.7
10. EDI	31	30	16.7	16.1
11. MRP	20	12	10.8	6.5
12. NC Machine	19	7	10.2	3.8
13. P-O-S Systems	15	5	8.1	2.7
14. CIM	14	3	7.5	1.6
15. Expert Systems	6	2	3.2	1.1
16. Decision Support Systems	5	4	2.7	2.2
17. Robotics	5	1	2.7	0.5

Continue Table 5.11

Main Business Activities	Manual	Computerised	% Manual	% Computerised
1. Accounting/Finance	4	182	2.2	97.9
2. Invoice/billing	17	163	9.1	87.6
3. Credit Control	30	145	16.1	78.0
4. Sales	36	126	19.4	67.7
5. Forecasting	26	116	14.0	62.4
6. Purchasing	61	101	32.8	54.3
7. Inventory Control	36	96	19.4	51.6
8. Fixed Asset	39	84	21.0	45.2
9. Supplies	45	78	24.2	41.9
10. Material Control	45	77	24.2	41.4
11. Customer Services	64	71	34.4	38.1
12. Marketing/Advertisement	79	60	42.5	32.3
13. Contracts	62	58	33.3	31.2
14. Production Operation	50	53	26.9	28.5
15. Personnel Management	94	52	50.5	28.0
16. Project Management	62	43	33.3	23.1
17. Distribution	24	41	12.9	22.0
18. Engineering	39	37	21.0	19.9

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

belonging to the mini's and mainframe family. As servers facilitate resource sharing among PC users, it is logical to assume that firms with servers would tend to have more PCs than those without. The sample data suggests that those who indicated using mini's or mainframes have higher number of PCs with an average of 15.9 compared to 12.1 for those without.

In terms of using external computer services and outsourcing, smaller proportion of firms in the sample make use of third party services for their IT adoption. The figure suggests only 21.5% of firms used external services for their computer needs and an even smaller 4.8% of the sample engaged in outsourcing. This suggests the sample firms' preference for in-house implementation and development of their information systems and further supported the claims that small firms are ill equipped financially to seek external services.

Apart from computers firms are also using other IT products in support of their business. Among the most popular communications and networking facilities facsimiles (fax) appears to be as important if not more important than telephones as tools to support the business. All firms in the sample indicated using fax to support their business and with the pervasiveness of the mobile telecommunication technology, it is not surprising to find some firms using mobile phones in place of the traditional telephones as suggested by the data. The use of modems by almost 84% of the sample suggest the significance of inter-firm electronic communications where there is a need to transfer data and information across the wide area network.

Analysis on the use of systems software reveals that word processing systems is the most popular systems adopted by almost 98% of the sample firms. This is followed by spreadsheets (91.9%), database (81.2%), and to a lesser extent mail merge (51.1%) and the Internet (45.7%). Table 5.11 above lists all the systems software used by order of current popularity. In terms of future software requirements, the Internet seems to be the most promising with 34.4% of the sample plan to acquire the software. Other most popular planned software acquisitions include electronic mail with 26.9%, electronic data interchange (EDI) with 16.1% and CAD/CAM with 10.8%.

In terms of business activities, almost 98% of the firms had their accounting and/or financial systems fully or partly computerised. This is consistent with other studies that found the accounting/financial systems as the most computerised of all applications within the small firms. Other business activities high in the computerised list include the invoice and billing systems with 87.6%, the credit control systems with 78.0%, sales with 67.7%, forecasting with 62.4%, purchasing with 54.3%, and inventory control systems with 51.6%. Activities that are predominantly manual are personnel management systems (50.5%), marketing/ advertisement (42.5%), contract and project management both at 33.3%. A complete list of the computerised and manual business applications is shown in Table 5.11 ordered by the most number of applications computerised.

Table 5.12 summarised the total number of IT adoption in regards to the total number of IT products used, the total number of systems software used, the total number of systems planning to use, and the total number of computerised applications. Except for Total Systems Planned, almost all firms indicate their present IT requirements with a mean of 4.8 IT products, 5.8 systems and 7.9 computerised applications. In terms of the number of systems planned 102 of the respondents indicate their plan to acquire between 1 to 7 systems with an average of 2.3. Results of the IT adoption gave some indication of the extent of the use of IT of firms in the sample and will later be used in the analysis of IT and EUC sophistication of small firms.

Table 5.12. Summary of IT adoption

Variables	N	Min.	Max.	Mean	Std. Dev.
Total IT products	185	3	8	4.85	1.12
Total Systems Software	184	1	15	5.82	2.44
Total Systems planned	102	1	7	2.29	1.29
Total Computerised Applications	186	0	18	7.89	3.85

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

5.1.3. Analysis of the Firm's EUC practice

In the area of end-user computing, there is a growing trend in EUC practice based on the data in the sample firms. This is a significant development as previous studies have shown very limited EUC activities among small firms. As has been discussed earlier in Chapter 3 the EUC phenomenon has been widely accepted in large organisations but little is known of its development in small firms. This is because of the nature of small business with limited resources and lack of access to technical expertise. Results from this survey have however revealed more firms are adopting EUC with 95 respondents indicated their firms are involved in EUC. This represents slightly more than half of the sample firms (51.1%) that use their computers to develop their own applications.

Results of the respondent's choice of software used for development are presented in Table 5.13 below. Spreadsheets are the most popular tool for end-user application development with 97.9% of the sample used this tool to develop their applications. Within this, Microsoft Excel is the top choice for the type of spreadsheet used with 58.9% of the sample. Lotus 1-2-3 is second with 22.1% and this is followed by Microsoft Words (5.3%), Supercalc (4.2%) and Quattro Pro (2.1%).

The second most popular development tool is word processors with 80.1% response. Microsoft Word appears to be the top choice for word processing development with 50.5% response. Other less preferred choices include Lotus, Word Perfect, Ami-Pro, Microsoft Works, Microsoft Excel and Wordstar. Interestingly, Wordstar that was once a popular word processing system is not considered to be a popular development tool for word processing typed applications.

Table 5.13. Types of Development Tools used

Development Tools	Frequency	Percentage	Cum. Frequency	Cum. Percentage
I. Spreadsheet				
MS-Excel	56	58.9	56	58.9
Lotus 1-2-3	21	22.1	77	81.0
MS-Word	5	5.3	82	86.3
Supercalc	4	4.2	86	90.5
Quattro Pro	2	2.1	88	92.6
Others	5	5.3	93	97.9
II. Word Processors				
MS-Word	48	50.5	48	50.5
Lotus 1-2-3	7	7.4	55	57.9
Word Perfect	6	6.4	61	64.3
Ami-Pro	4	4.2	65	68.5
MS-Works	3	3.2	68	71.7
MS-Excel	2	2.1	70	73.8
Wordstar	2	2.1	72	75.9
Others	4	4.2	76	80.1
III. Database				
MS-Access	26	27.4	26	27.4
MS-Word	6	6.4	32	33.8
Lotus 1-2-3	5	5.3	37	39.1
MS-Excel	4	4.2	41	43.3
Paradox	3	3.2	44	46.5
dBase	3	3.2	47	49.7
MS-Works	3	3.2	50	52.9
Others	23	24.2	73	77.1
IV. Programming Lang.				
Visual Basic	6	6.4	6	6.4
C++	2	2.1	8	8.5
Progress	2	2.1	10	10.6
Others	12	12.6	22	23.2
V. Graphics				
CorelDraw	2	2.1	2	2.1
Internet	1	1.1	3	3.2
AutoCAD	1	1.1	4	4.3
Adobe Illustrator	1	1.1	5	5.4
Others	5	5.3	10	10.7

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

Next are database packages with 77.1% response. Microsoft Access tops the list of database development tools with 27.4% response. Following this are Microsoft Word, Lotus, Microsoft Excel, Paradox, dBase and Microsoft Works. Here again the Microsoft suite of packages dominates the application development tools and interestingly some of these packages are not Database Management Systems (DBMS) software. This may suggest a fairly simple and straightforward approach to database application development is being adopted mostly for record-keeping and transaction-based processing among the sample small firms.

To a lesser extent, programming languages and graphics packages are also used for user development. These include Visual Basic, C++, Progress, CorelDraw, the Internet, and AutoCAD. Others include Java, Pascal, Adobe Illustrator, and others not mentioned by name.

Apart from the software used for application development, analysis was also done to examine and identify the distribution of the application development environment. For each development tool the development environment was analysed that includes the names of the applications developed, the developer(s) who developed the applications, and the number of end-users using the applications. Table 5.14 below presents the results of the various application development environments. The information will also be used later to form part of the EUC sophistication construct.

Part I of Table 5.14 shows the application development environment using spreadsheet, which the most popular development tool for EUC as discussed earlier. Within this, the most popular application developed is the financial application. This includes cost estimates, budgetary controls and other accounting applications. However based on the data presented only 37 respondents out of the total of 93 who used spreadsheets to develop their applications have actually named the applications as listed in Part I a) of Table 5.14.

In terms of the developer, it is interesting to note that almost 64% who responded identified him/herself as the developer of the spreadsheet applications either singly or with other end-users ('respondent' and 'respondent & end-users' categories). The fact that more than 90% of the respondents are from the middle-top management further suggests the significant contribution of the managerial-level personnel to EUC. On the number of end-users using the EUC applications the data suggests fewer end-users tend to use the application. This may indicate the development of spreadsheet applications tend to be for the individuals who develop them or for use by small group of other users.

For word processing the range of applications that can be developed is even more limited. The only suitable application appears to be document creation and maintenance such as form letters, quotes, mail shots, manuals and contracts. The

Table 5.14. Distribution of the Application Development Environment

Application Development Environment	Frequency	Percentage
I. Spreadsheets		
a) Name of Main Applications		
Financial Applications	17	45.9
Order Processing	2	5.4
Inventory Control	2	5.4
Forecasting	2	5.4
Others	14	37.9
b) Developer		
Respondent	26	36.1
Other End-User(s)	24	33.3
Respondent & End-User(s)	20	27.8
IT Prof/3rd Party	2	2.8
End-Users & IT Prof.	0	0.0
c) No. of End-Users		
1 - 5	58	76.3
6 - 10	13	17.1
11 - 20	4	5.3
21 and above	1	1.3
II. Word Processing		
a) Name of Main Applications		
Document Maintenance	10	55.5
Others	8	44.5
b) Developer		
Respondent	8	15.1
Other End-User(s)	28	52.8
Respondent & End-User(s)	13	24.5
IT Prof/3rd Party	3	5.7
End-Users & IT Prof.	1	1.9
c) No. of End-Users		
1 - 5	35	59.3
6 - 10	14	23.7
11 - 20	5	8.5
21 and above	5	8.5
III. Database		
a) Name of Main Applications		
Financial Applications	5	15.2
Document Maintenance	4	12.1
Customer services	4	12.1
Inventory Control	3	9.1
Others	17	51.5
b) Developer		
Respondent	21	38.2
Other End-User(s)	18	32.7
Respondent & End-User(s)	9	16.4
IT Prof/3rd Party	6	10.9
End-Users & IT Prof.	1	1.8
c) No. of End-Users		
1 - 5	45	76.2
6 - 10	4	6.8
11 - 20	5	8.5
21 and above	5	8.5

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

majority of the developers as suggested by the data seem to come from other end-users with 52.8% of the response. These end-users presumably belonged to the administrative and clerical staff judging from the nature of the applications and the fact that word processing has come a long way in supporting secretarial and clerical works. Like spreadsheet applications, fewer numbers of end-users tend to use a word processing application but unlike spreadsheet applications they tend not to be used individually.

Part III of Table 5.14 analyses the application development environment for database. The main applications developed tend to vary from financial applications to document maintenance, customer information and inventory control. However as with spreadsheet and word processing, only a small number of respondents have actually named the applications that were developed. As in spreadsheet, the respondent develops most of the applications alone or in combination with other end-users. It is also interesting to note that unlike spreadsheet and word processing development, database development tend to involve more IT professionals and third parties. This may suggest the complexity of database development, which require the developer to be technically conversant in database design and implementation issues. The data on the number of end-users using the database applications also suggest smaller group and individual usage with 76.2% of the response indicated between 1 to 5 end-users.

In summary the data presented in Table 5.14 suggests that most applications developed by end-users are financial and accounting based, and to a lesser extent document maintenance, inventory control and customer/order information. The developers of these applications are largely knowledgeable people representing the upper echelons of the small firms and they tend to develop the application individually or with the help of other end-users. The nature of the applications seems to be specialised and tailored to individual business processes and smaller work-groups as opposed to organisation-wide.

In terms of user satisfaction, 88.4% of the respondents indicated that they are satisfied with the applications they developed with a mean score of 3.79 on a 5-point scale (1=not satisfied to 5=very satisfied). This supports previous research that suggests users tend to be more satisfied with the applications they developed. Only one respondent indicated not satisfied with the applications. This is also consistent with the view that since they generally know their business requirements well, users could become good application developers. Table 5.15 below summarised the user satisfaction score based on the EUC responses.

Table 5.15. User Satisfaction Score for End-User Developed Applications

User Satisfaction	Frequency	Percentage	Cum. Frequency	Cum. Percentage
Not Satisfied (score 1)	0	0.0	0	0.0
Less Satisfied (score 2)	1	1.1	1	1.1
Average Satisfied (score 3)	37	38.9	38	40.0
More Satisfied (score 4)	26	27.4	64	67.4
Very Satisfied (score 5)	21	22.1	85	89.5
Not Responded	10	10.5	95	100.0

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

Critiques of EUC contend that applications developed by end-users tend to be non-standardised, lacked in quality and not efficient. However, because of financial constraints and the lack of professional IT development resources, yet faced with the urgency to automate business processes, many users appear to consider the advantages associated with computerisation outweigh the risks associated with self developed applications. Despite these problems, when respondents were asked whether it is useful for end-users to develop their own applications 42.4% believed it was useful. Among the reasons given were user's requirements are better met, improvement in efficiency, encourages good team spirit, and the believe that applications are nowadays much easier to develop and doing one's own development costs less. On the contrary, the majority respondents who rejected the idea of EUC thought that the development work is too time consuming and difficult to manage. They believed that users are not adequately trained in using development tools and argued that users were not employed to developed applications. Few respondents believed that self-development is too expensive and the resulting applications are non-standardised. Finally when asked whether their firms are interested to be involved in an EUC investigation, 35.5% of the respondents said they were interested and out of these 40.9% came from firms with no EUC activity. More surprising is that nearly half (48.3%) of those who responded to the question on usefulness of EUC and indicated their interest to be involved in the EUC investigation came from those respondents who rejected the idea of EUC. The results may suggest the growing trends of EUC in small firms consistent with the suggestion made in other related studies. Table 5.16 presents the distribution of the respondent's interest in EUC based on firms with EUC presence and usefulness of EUC to the firm.

Table 5.16. Distribution of Respondent's Interest in EUC by EUC Presence and Usefulness of EUC

	Interest in EUC Investigation		Not Interested in EUC Investigation		Total	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
EUC Presence	39	59.1	56	46.7	95	51.1
No EUC Activity	27	40.9	64	53.3	91	48.9
Useful to have EUC	30	45.5	40	33.3	70	37.6
Not useful to have EUC	28	42.4	67	55.8	95	51.1
No Response	8	12.1	13	10.8	21	11.3

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

5.1.4 Cross-Tabulation of the Firm's Profile, IT Adoption and EUC Practice

Cross-tabulation was done to examine the relationships between and among specific variables in various parts of the questionnaire involving the firm's profile, IT adoption and EUC presence. The aim is to gain insight into the behavior of certain categories of data in order to further understand the sample data and provide a preliminary analysis of the relationships among the variables that made up the EUC sophistication construct. Among the combination of variables cross-analysed are Size of Firm with IT Adoption and EUC Presence. Firm's Age with IT Adoption and EUC Presence, Industry with IT Adoption and EUC Presence, and IT Adoption and EUC Presence.

Table 5.17 shows the result of the cross tabulation between Firm Size and IT Adoption and Firm Size and EUC Presence. Firm Size is based on the Size Band defined earlier according to the number of employees. IT Adoption is represented by the Number of Years using IT Category though this may not represent the true measure of IT Adoption but it should be interesting to examine the relationship between Firm Size and the number of years a firm had adopted IT. A dichotomous variable was used to measure the presence of EUC that was taken directly from the questionnaire.

Table 5.17. Cross Tabulation of Firm Size with IT Adoption and EUC Presence

	Years Using IT									Presence of EUC			
	0-5 Years			6-10 Years			Above 10 Years			Yes		No	
Size Band	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	%	N	%
'Small' Small (0-9)	1	1.00					3	14.00	1.73	3	50.0	3	50.0
'Medium' Small (10-49)	24	3.25	1.11	43	8.79	1.55	37	14.08	2.25	60	53.1	53	46.9
'Large' Small (50-99)	11	3.09	1.51	22	9.00	1.45	20	14.80	2.63	28	50.0	28	50.0
Total	36	3.14	1.27	65	8.86	1.51	60	14.32	2.35				

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

Analysis of the Firm Size and IT Adoption shows a slight increase in the average number of years using IT between the 'medium' and 'large' small categories for those using IT for more than 5 years. The data suggests the larger the size of the firms, the longer they tend to be using IT. This is consistent with many surveys of IT adoption found in the literature. However the data seems to suggest that there are more firms in both 'medium' and 'large' small categories within 6-10 years of using IT than there are above 10 years or below 6 years.

In terms of EUC Presence more firms in the 'medium' size band tend to practice EUC. However within the 'large' small category the proportion of firms who practice EUC appears to be the same as those who did not practice EUC. No analysis was however done on the 'small' size band category, as the sample is too small to give any meaningful interpretation. The results therefore did not support linear relationship between Firm Size and number of Years using IT and relationship between Firm Size and the Presence of EUC.

Table 5.18 presents the result of the cross tabulation between Age of Firm with IT Adoption and EUC Presence. Though there are slight increase in the average number of years using IT in the higher age groups with the number of years using IT the smaller sample sizes in these groups may not support the suggestion. However on the Presence of EUC the proportion of firms tend to increase with age. This suggests that established firms tend to practice EUC more than newer firms, though the same cannot be supported for those firms that have adopted IT longer.

Table 5.18. Cross Tabulation of Age of Firm with IT Adoption and EUC Presence

	Years Using IT									Presence of EUC			
	0-5 Years			6-10 Years			Above 10 Years			Yes		No	
Firm Age (years)	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	%	N	%
0 - 10	13	3.15	1.21	9	7.89	1.76	4	15.50	3.32	15	50.0	15	50.0
11 - 50	19	3.26	1.19	44	8.89	1.56	28	13.86	2.21	51	53.1	45	46.9
51 - 100	1	1.00		7	8.86	1.21	16	14.31	2.12	14	53.8	12	46.2
100+	1	5.00		7	9.29	1.25	12	14.58	2.15	12	54.5	10	45.5

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

A cross tabulation of Industry Composition with IT Adoption and EUC Presence is presented in Table 5.19. The data is quite consistent across the Manufacturing, Services and Construction industries with greater proportion of firms fall within the 6-10 years of adopting IT. The Manufacturing sector tends to have the longest IT experience in all three categories of Years Using IT. The Services sector has the highest proportion of firms adopting IT in the last 10 years with nearly 70% of all firms in this sector adopts IT within this period. For firms that used IT for more than a decade, greater proportion of firms are found within the Wholesale and Retail industry, but this result was suspected, as the sample size for this industry was too small. The Wholesale and Retail industry has also the least number of IT experience compared to other industries in the more than 5 years of using IT categories. In terms of the presence of EUC the data suggests that firms within the Services, Construction and Wholesale and Retail industries develop more of their own applications with the Professional Services industry tops the list. The Manufacturing industry has however fewer firms with EUC presence. Again the Agricultural sector was not included in the analysis because of the small sample size.

Table 5.19. Cross Tabulation of Industry Composition with IT Adoption and EUC Presence

	Years Using IT									Presence of EUC			
	0-5 Years			6-10 Years			Above 10 Years			Yes		No	
Firm Age (years)	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	%	N	%
Manufacturing	19	3.32	1.25	38	9.03	1.30	34	14.62	2.67	49	48.5	52	51.5
Services	3	2.33	0.58	9	8.89	1.76	6	13.67	1.37	10	47.6	11	52.4
Construction	5	3.00	2.00	10	9.30	1.49	9	14.33	1.32	13	54.2	11	45.8
Wholesale & Retail	2	3.00	1.41	5	7.40	1.67	9	13.33	1.41	10	58.8	7	41.2
Professional Services	7	3.14	1.07	8	8.00	1.77	5	14.60	3.29	13	59.1	9	40.9

Note: Frequency for the "NO RESPONSE" type has been excluded in this table and this explains the variable total number of responses.

A cross tabulation of IT Adoption and EUC Presence shows no particular forms of relationship exists between the number of years using IT and the presence of EUC. The distribution of data as presented in Table 5.20 below shows a somewhat evenly distributed proportion of firms across the IT Adoption ranges for both categories of firms with and without EUC Presence. This may suggest an initial proposition that the presence of EUC in small firms is independent of the number of years of using IT. Further analysis to explore the relationship between EUC and IT Adoption was made by measuring their levels of sophistication and examining their relationship along with other factors in the EUC Sophistication construct. These will be examined in the sections that follow.

Table 5.20. Cross Tabulation of IT Adoption and EUC Presence

	Presence of EUC			
	Yes		No	
Years using IT	N	%	N	%
0 - 5 years	19	51.4	18	48.6
6 - 10 years	35	50.0	35	50.0
10 years and above	32	50.8	31	49.2

Note: Frequencies for the "NO RESPONSE" type have been excluded in this table and this explains the variable total number of responses.

5.2. OPERATIONALISATION OF THE SOPHISTICATION INDEX

5.2.1. Background

The source of data for operationalisation of the sophistication index came from results of the survey. The measurements for IT Sophistication Index (ITSI) and EUC Sophistication Index (EUCSI) are based on the Software Sophistication Index (SSI) developed by Kagan et al. (1990) as described previously in Section 2.5. Using the application mean scores from the original Kagan's SSI construct as tabulated in Table 2.3, raw scores were calculated for all firms based on the Sophisticated Score Construction formula. However, since the raw scores are based on the list of 12 IT products (see Table 2.3) used by Kagan et al. (1990) in their study, they may not accurately represent the firm's overall level of sophistication in this study. This is because there are more IT products and applications developed by end-users (EUC applications) included in the sample survey compared to the Kagan's list. If the Kagan's list were to be used, those IT products and applications that have not been accounted for may also have some effect on the level of sophistication. This is not desirable, as the firm's level of IT and EUC sophistication would have been misrepresented.

Hence, Kagan's weighting scheme has to be extended to cover all variability. To achieve this, the sophistication index for both ITSI and EUCSI measurements will need to be re-calibrated. Furthermore, for EUCSI measurement, modifications are made to the Kagan's formula as discussed previously in Section 3.5 and summarised in Figure 3.10. These modifications include the addition of two other sophistication constructs, that is End-User Sophistication and Usage Sophistication constructs into the original SSI construct to accurately represent the definition of EUC Sophistication as suggested by Blili et al. (1996).

It is important that such indexes are re-calibrated particularly since Kagan's index has been in existence for a decade. The rapid growth of IT and development methodology may have changed the degree or order of the sophistication indexes. Hence the 'new' index should reflect the current sophistication so that analysis of the factors contributing to EUC Sophistication performed in this study would more accurately represent the current context. The 'new' index could also allow comparisons to be made by observing trends that could have changed with respect to the sophistication of IT products and applications. In addition, the 'new' index would also take into account other emerging technology that may not have existed or was less significant when Kagan et al. (1990) did their study. This reasoning was supported by some of the findings on ITSI and EUCSI presented in the next two sections.

In line with the preceding discussion, as an on-going concern it would be beneficial to conduct further studies similar to Kagan's and alternating these studies with the re-calibration technique used in this study. This would not only help validate the index but also update the index to reflect the current situation. Through these continuous efforts improvement to the accuracy and practicality of the sophistication indexes could be achieved.

5.2.2. Operationalisation of IT Sophistication Index

For the re-calibrated ITSI measurement the list of IT products, Systems Software and Main Business Activities (IT products) shown in Table 5.11 and reproduced here in Table 5.21 below was used. Only one construct, the Software Sophistication Index (SSI) described previously in Section 3.5 and summarised in Figure 3.11, was used to measure the small business IT sophistication level. All the 43 IT products (variables) shown in Table 5.21 were taken from responses to questions 15, 16 and 17 of the questionnaire. Each IT product used by the firm was coded as '1' or a '0' to indicate otherwise. Using Kagan's Software Sophistication Index instrument, a Sophistication Index score was calculated for all firms in the sample and a variable, KSSI (for Kagan's Software Sophistication Index) was created to store the value in the sample database. This becomes the Dependent Variable (DV) where a stepwise regression procedure will be performed to predict which of the enlarged and updated list of 43 IT products best matched Kagan's Sophistication Index. Note that Kagan has only 12 IT products that are also included in the questionnaire. Hence the DV (KSSI) was based on these 12 IT products.

Using the regression procedure the 43-item IT variables were tested using the results of the survey to identify which variables are the best predictors of Kagan's original index. This was done by performing stepwise regression on all the 43 IT variables (as binary variables) against the DV (KSSI). The idea was to predict which of the 43 IT products (independent variables) that best fit the original Kagan's SSI (DV). Variables that fail to fall along the data points that form a linear relationship between the dependent and independent variables at a pre-defined significant level will be removed by the stepwise regression procedure. Using the appropriate statistical analysis explained later in this section, the new re-calibrated IT ranking was found to be consistent with Kagan, and therefore was used with confidence to measure the new ITSI for the firms in the sample.

The result indicated 14 variables found to be significant at the 0.001 level. Unstandardised Beta Coefficients (Regression Coefficients) associated with each variable were used as the new weighted score. Unstandardised coefficients are used as opposed to standardised coefficients because they represent the predicted values of the independent variables based on their original units of measure. Standardised coefficients on the other hand are the regression coefficients when all independent variables are transformed to a standardised (z-score) form so that they all have the same units of measure. Table 5.21 shows the result of the regression analysis on the 43 IT variables along with the coefficients, *p* value and the corresponding Kagan's software checklist.

Table 5.21 IT Sophistication Variables

IT Products	**Unstandardised Beta Coefficient**	**Significance (*p* value)**	**Kagan's checklist**
1. Fax*	N/A	N/A	
2. Telephone	0.001	0.877	
3. Mobile Phone	-0.018	0.068	
4. Modem	0.000	0.985	
5. PABX	-0.017	0.084	
6. Electronic Organiser	-0.008	0.401	
7. Network hub,router	-0.005	0.621	
8. Tele/Video Conferencing	0.013	0.186	
9. Word Processing	0.015	0.144	3
10. Spreadsheet	4.902	0.001	3
11. Database	5.785	0.001	3
12. Mail Merge	-0.015	0.120	
13. Internet	4.688	0.001	
14. Electronic Mail	-0.012	0.334	
15. Graphics	-0.004	0.705	
16. CAD/CAM	0.000	0.988	
17. Desk-Top Publishing	-0.005	0.603	
18. EDI	2.727	0.001	
19. MRP	-0.003	0.789	
20. NC Machine	-0.002	0.828	
21. P-O-S Systems	-0.013	0.184	
22. CIM	0.009	0.336	
23. Expert Systems	0.011	0.261	
24. Decision Support System	3.330	0.001	
25. Robotics	0.003	0.786	
26. Accounting/Finance	3.908	0.001	3
27. Invoice/billing (pricing)	4.819	0.001	
28. Credit Control	-0.011	0.287	3
29. Sales	2.287	0.001	
30. Decision Model (Forecasting)	7.898	0.001	3
31. Purchasing	1.159	0.001	3
32. Inventory Control	4.394	0.001	3
33. Fixed Asset	4.869	0.001	
34. Supplies	-0.012	0.303	3
35. Material Control	0.006	0.606	3
36. Customer Services (data)	5.058	0.001	
37. Marketing/Advertisement	0.013	0.230	
38. Contracts	-0.014	0.152	3
39. Production Operation	0.000	0.967	
40. Personnel Management	4.427	0.001	
41. Project Management	-0.007	0.497	
42. Distribution	-0.015	0.148	
43. Engineering	-0.002	0.801	3

Note: *Items in **bold** are significant at the 0.001 level.*
**Item is a constant because it is used by all firms in the sample.*

The 14 IT products (in bold letters above) became the variables used in the re-calibrated IT sophistication index. With the exception of Word Processing and Telecommunication products, all other variables found to be significant in the regression analysis were similar to the original Kagan's software list. Word Processing was excluded by the regression procedure because it was not found to be significant even at the 0.1 level. This is expected as almost all (98%) of firms in the sample indicated having Word Processor (see Table 5.11) so there was less discriminating power to distinguish the significance of Word Processing in the sample. Telecommunication was not identified as a single product in this study but a variety of different applications. These include fax, telephone, mobile phone, modem, PABX, network hubs, tele/video conferencing, the Internet, electronic mail and electronic data interchange (EDI). With the exception of the Internet and EDI, all other telecommunication applications were not found to be significant at the 0.05 level. Fax however was treated as a constant because all the firms in the sample use it.

Three new variables not in the Kagan's list were found to be significant predictors for the re-calibrated IT sophistication index. They are the Internet, Electronic Data Interchange (EDI) and Decision Support System (DSS). Incidentally these three products have also been the topics of much discussion recently. This is consistent with the software identified by Kagan et al. (1990) in the original opinion survey that was based on the most popular software and applications used by small business.

Comparing the weighted score between the re-calibrated scores and Kagan's mean scores, most of the re-calibrated scores seem to be in agreement with Kagan's mean scores. However both the re-calibrated scores for Purchase and Sales Order Processing carry less weight than Kagan's Order Processing mean score. On the other hand the re-calibrated scores for Spreadsheet and Pricing applications carry slightly more weight than the corresponding Kagän's mean scores. The rest of the scores differ only slightly and can be accepted as having equivalent in weight. Table 5.22 shows the weighted scores and ranking between the re-calibrated and Kagan's mean scores. Note that for the sake of comparison, only those software/IT products that appear in both the scores are included in the table.

Table 5.22 IT Sophistication Score Ranking

Kagan's Score			Re-calibrated Score		
Rank	**Software**	**Weighted Score**	**Rank**	**IT Product**	**Weighted Score**
1	Accounting & Finance	3.26	1	Order Processing	1.723*
2	Order Processing	4.03	2	Accounting & Finance	3.908
3	Spreadsheet	4.03	3	Inventory Control	4.394
4	Pricing	4.08	4	Employee/Personnel	4.427
5	Employee/Personnel	4.19	5	Pricing	4.819
6	Inventory Control	4.64	6	Fixed Asset	4.869
7	Fixed Asset	4.75	7	Spreadsheet	4.902
8	Data Applic. (Customer)	5.16	8	Customer Services (Data)	5.058
9	Database	6.13	9	Database	5.785
10	Decision Model	7.83	10	Decision Model	7.898

Note: *Weight is taken as the average of Purchase and Sales Order Processing scores

The result of the regression analysis presented in Table 5.21 shows that the order processing software (both Sales and Purchasing) was ranked the least sophisticated. This may suggest that the automation of order processing activities in small business involves simple data entry to capture customer order and printing of order receipts, without the complexity of integrating with the production system and inventory control to process the order and monitoring order-in-progress. EDI was also ranked less sophisticated, occupying second position after Purchase and Sales Order Processing. This may suggest that a less sophisticated development is required to use the EDI package other than simply establishing links to the telecommunication facility with minimal manipulation of parameters and settings to create and transfer documents. Surprisingly, DSS was rated moderately lower and again this may suggest that the presence of DSS in small business may involve simple problem-solving/decision-making models with few parameters using simple "what-if" analysis. On the other hand, surprisingly too, Spreadsheet was rated much higher (fourth highest compared to third lowest in Kagan's list). This could well explain the trend today where Spreadsheet is being used to perform more sophisticated and complex tasks as businesses meet the many challenges of today compared to when it was 10 years ago when Kagan et al. (1990) did their study.

Using the IT Sophistication Score Ranking of Table 5.22, the reliability of the re-calibrated score can also be determined by performing the Spearman's Rho Rank-Order Correlation to see whether the re-calibrated scores are ranked according to Kagan's score ranking. A coefficient close to 1.0 is interpreted as both scores having similar ranking order and therefore the use of the re-calibrated scores are said to be reliable as they closely match the original opinions of the IT experts in the Kagan et al. (1990) study. A coefficient of 0.0 means the re-calibrated score is not ordered according to Kagan's score ranking and the resulting IT sophistication index can either suggest major changes in the degree of sophistication of the IT products used by the small business or the reliability of the index may be suspect.

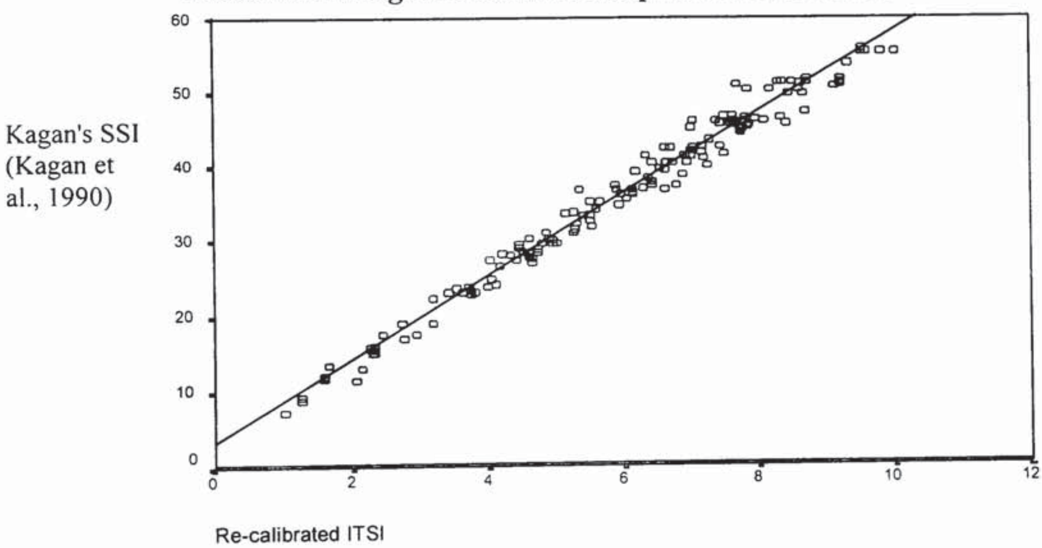
Result of the Spearman's Correlation produces a coefficient of 0.745 at the 0.05 level of significance. This means the relationship between the Kagan's rankings and the re-calibrated score ranking is high suggesting agreement between the two rankings. This may also suggest some changes are expected with respect to software ranking that had occurred over the 10-year period as IT is evolved within the small business. This therefore suggests that the re-calibrated IT sophistication scores are reliable and therefore represent good predictors of the opinions of the IT experts with a reasonably high level of confidence.

According to Emory and Cooper (1991, p. 185) a measurement is said to be reliable if it produces consistent results. The authors contend that if an alternative form of the same measure produce the same or similar results, then reliability is achieved. The preceding discussion has demonstrated that the ranking of the re-calibrated scores are highly related to the ranking in the Kagan's scores. However, the same authors contend that while reliability is necessary, it is not sufficient to validate a measure. Validity can be achieved by correlating the results of an available measure (in this case the Kagan's SSI construct) with those derived from a new measure (ie. the re-calibrated ITSI construct).

To determine the validity of the ITSI construct, strong relationships should exist between the re-calibrated ITSI construct and the original construct based on Kagan's SSI. A correlation coefficient close to ± 1.0 would suggest a strong relationship between the two constructs and therefore the ITSI construct is said to be valid. A coefficient of 0.0 would suggest otherwise. A Bivariate Pearson Product Moment Correlation Coefficient was used to test the relationship between the two constructs. However, before this test can be done both the re-calibrated ITSI and Kagan's SSI were computed for all firms in the sample. Kagan's SSI computation was described previously in Section 2.5 whilst the details of the re-calibrated ITSI formulation will be discussed later in this section.

The result of the Pearson Correlation test indicates a strong relationship exists with coefficient of 0.993 at the 0.01 level of significance. This can be visualised by drawing a scatterplot of the linear regression that best fits the data points between the re-calibrated ITSI and the original Kagan's SSI as presented in Figure 5.1 below. A strong relationship is apparent as the data points cluster close to the straight line passing through the data as shown in the figure. This proves that the re-calibrated ITSI can make a good prediction of the original Kagan's index and therefore are used as the measurement for ITSI in this study.

Figure 5.1. Scatterplot of re-calibrated IT Sophistication Index with Kagan's Software Sophistication Index



IT Sophistication Index (ITSI) can now be computed by calculating the total weighted score of all corresponding IT products used by the firm. The technique similar to the Sophisticated Score Construction described in Table 2.3 was used with the following formula:

$$\text{Total Weighted Score} = \sum_{i=1}^{n} (\text{weighted score for application i}) * \delta_i$$

Where δ_i = 1 if the firm uses application i
= 0 otherwise
n = total number of applications

The Total Weighted Score above is the raw form of ITSI and need to be transformed so that its value falls within the range 1 to 10. The aim is to obtain a sophistication index similar to the original scale so that the same interpretation on the level of the firm's IT sophistication can be applied. That is, an ITSI of 1 is rated as the least sophisticated and 10 is rated as the most sophisticated among the sample firms. The following is the formula for the ITSI transformation:

ITSI = (Total Weighted Score + a) / b

Where a and b are chosen such that $1 < \text{ITSI} < 10$
and $10 = (max + a) / b$
$1 = (min + a) / b$

Where *max* is the maximum Total Weighted Score of a firm in the sample
and *min* is the minimum Total Weighted Score of a firm in the sample.

In order to demonstrate how an ITSI of a firm is calculated using the above Sophistication Index formula, consider a firm that uses the following hypothetical IT products:

> Fax, Mobile Phone, Telephone, Modem, **Spreadsheet**, **Customer Services**, Word Processing, **Accounting & Finance**, **Decision Model** for Forecasting, **Pricing**, **Personnel**, **Sales**.

The first step is to identify which IT products in the list above are to be included in the Sophistication Index formula. This can easily be done by matching the 14 highlighted list of IT products shown in Table 5.21 with the above list. Those products in bold above are the ones that matched. Using the Sophistication Index formula above the Total Weighted Score for the firm is calculated as follows:

Total Weighted Score = (Weighted Score for **Spreadsheet** * 1) + (Weighted Score for Database * 0) + (Weighted Score for Internet * 0) + (Weighted Score for EDI * 0) + (Weighted Score for DSS * 0) + (Weighted Score for **Accounting/Finance** * 1) + (Weighted Score for **Pricing** * 1) + (Weighted Score for **Sales** * 1) + (Weighted Score for **Decision Model** * 1) + (Weighted Score for Purchasing * 0) + (Weighted Score for Inventory Control * 0) + (Weighted Score for Fixed Asset * 0) + (Weighted Score for **Customer Services** * 1) + (Weighted Score for **Personnel Management** * 1)

Note: To aid readability, products used by the firm are shown in bold in this example.

Substituting the weighted scores using the unstandardised coefficients of Table 5.21,

Total Weighted Score = (4.902 * 1) + (5.785 * 0) + (4.688 * 0) + (2.727 * 0) + (3.330 * 0) + (3.908 * 1) + (4.819 * 1) + (2.287 * 1) + (7.898 * 1) + (1.159 * 0) + (4.394 * 0) + (4.869 * 0) + (5.058 * 1) + (4.427 * 1)
= 4.902 + 3.908 + 4.819 + 2.287 + 7.898 + 5.058 + 4.427

Total Weighted Score = 33.299

Before the firm's ITSI can be calculated, Total Weighted scores for all firms in the sample will have to be calculated using similar steps above. This will allow the transformation formula to be computed since the minimum and maximum Total Weighted scores will also be known. Assuming that all the Total Weighted scores of the firms in the sample have been computed where *min* = 7.35 and *max* = 56.92 (these are actual *min* and *max* values based on the sample in this study), ITSI for the firm in this example is computed as follows:

ITSI = (Total Weighted Score + a) / b

Where a and b are chosen by solving the following equations:

$$10b = max + a = 56.92 + a$$
$$b = min + a = 7.35 + a$$

Hence, $a = -1.840$ and $b = 5.508$

Substituting the ITSI formula above,

$$\text{ITSI} = (33.299 - 1.840) / 5.508 = 5.712$$

In the above example, the firm's level of IT sophistication is said to be moderate compared to the minimum and maximum possible sophistication levels in the sample. In the context of the index, it can safely be deduced that the result represents sophistication from the perspective of the experts. It also represents actual sophistication level in relation to what is used in practice as opposed to theory.

The next section discusses the operationalisation of the EUC Sophistication index (EUCSI), which is basically the same as the operationalisation of the ITSI discussed in this section.

5.2.3. Operationalisation of EUC Sophistication Index

A similar approach was used to find a new re-calibrated EUCSI measurement. Whereas the ITSI was based on a prescribed lists of applications and IT products from the survey, the EUCSI being new, could not be based on similar prior lists. So a more open-ended question was used in the survey to produce the EUCSI instrument. Instead of using one construct as in the case of the ITSI measurement the EUCSI measurement takes three constructs as discussed previously in Section 3.5 and summarised in Figure 3.10. The closest instrument for EUC measurement that can be used was the one developed by Blili et al. (1996) following their definition of EUC Sophistication. Hence the three constructs are:

i. Application Sophistication
ii. End-User Sophistication
iii. Usage Sophistication

Whilst the intention (back to the aims of the study) is to produce an objective measurement to understand the extent small firms are capable of developing their own applications, Blili et al. (1996) did not used their measurement to calculate sophistication index. Blili et al. (1996) used their construct to aid large firms seeking to promote EUC sophistication and they identified a number of variables for this purpose but did not construct a single index. It was therefore decided to adapt the index construction approach of Kagan et al. (1990) to the construct space proposed by Blili et al. (1996) as presented earlier in Figure 3.10. Two options have been considered. (1) to repeat the scoring technique used by Kagan et al. (1990) by consulting a panel of experts, and (2) to use statistical fitting techniques to estimate the weights of the EUCSI using Kagan's scores. To perform (1) would require additional financial resources for the survey exercise (not withstanding the funds received from Aston University and Northern Malaysia University for the earlier survey and case study). Hence (2) was the only practical approach available to the researcher. However, it is recommended that the first option should be considered in the future to much more accurately represent opinions of experts.

Recall that for the Application Sophistication construct the re-calibrated measurement will be based on applications developed by end-users (EUC applications) as opposed to the list of IT products used in the ITSI measurement. For End-User Sophistication construct a single variable, type of end-user will be used based on a modified end-user typology from Rockart & Flannery (1983). Usage Sophistication construct is also a single item variable based on the number of users using the applications developed by end-users. The variable, Number of Users is used to keep a transformed value of the actual number of end-users between the range 1 to 10 since it is possible for a small firm to have the maximum number of end-users equivalent to the maximum firm size. If this were to be allowed the overall EUCSI of the firm will be invalid, as the Usage Sophistication score will dominate the sophistication index. The same transformation technique used in the preceding section was adapted for this purpose.

The sample data keeps track of all the EUC applications, the types of end-users and number of end-users in each individual firm that has EUC presence. Data and variables for the 3 constructs were taken from responses to Question 20 of the questionnaire (Appendix 1 of the thesis). Table 5.23 below represents the reply grid where the source of data were analysed and re-coded in the form of the three sophistication constructs.

Table 5.23. Reply Grid (Question 20)

(A) Development Tool	(B) Type of Software	(C) No. of Users	(D) Developer	(E) Name of Application
Spreadsheet				
Database				
Word Processing				
Programming Language				
Others				

For **Application Sophistication**, the names of all applications as shown in column E were analysed. As open answers were collected, similar answers were grouped to produce categories of EUC applications. The following are examples of the data that was grouped into categories of EUC applications:

Table 5.24. Examples of Data Responses grouped into categories of EUC Applications

EUC Application	Data Response
EUC Accounting/ Finance	"Cash Flow", "Costing", "Budget", "Accounting", "Payroll", etc.
EUC Personnel	"Personnel", "Staff", "Manning level"
EUC Customer Data	"Customer Information", "Customer Inquiry", "Customer Addresses"
EUC Production Operation	"Production Planning", "Production Development"

With Spreadsheet, Database and Word Processing applications cross-checked with the Type of Software (Column B of Reply Grid), a total of 13 EUC applications made up the Application Sophistication list as presented in Table 5.25. The list of types of EUC Applications was included as separate variables in the sample database. Each type of EUC application used by the firm was coded as '1'. Otherwise a '0' was coded to indicate the firm did not develop EUC application of that type.

For **End-User Sophistication**, the data collection column 'Developer' (column D of the Reply Grid) was synthesised to give the most appropriate End-User Typology on the scale "simple end-user", "command-level end-user", and "end-user developer". Criteria used as guidelines to help in the synthesis include:

"Simple End-User":	Generally word processing based, with no evidence of creating macros.
"Command-level End-User" :	Typically using spreadsheet or database tools, and tends to work individually or in a small group (1-2 people).
"End-User Developer" :	Typically using database and/or programming language development tool. Also depends on the application developed (column D) using Kagan's sophistication index as guidelines.

Where a range of end-user types exists, the overall end-user sophistication was characterised by the highest level typology. Whilst no specific guidelines or criteria were mentioned by Blili et al. (1996) or Zinatelli et al. (1996) in their studies, the above guidelines seem consistent with the typology defined by Rockart & Flannery (1983) and Dahalin & Golder (1998b). In constructing the numerical End-User Typology index, the values were coded 1, 2 and 3 in order.

In the case of **Usage Sophistication**, the column "No. of Users" (column C of the Reply Grid) was summarised for each firm to produce a single 'Total Number of Users'. The intention is not to know the actual number of users (addressed by question 12c of the questionnaire), but the degree of usage of the applications. The rationale is that the more applications are being used, the higher the usage and greater number of user activities covered. This will also affect the number of man-hours applications are being accessed, hence longer duration of usage. This rationale appears to be consistent with Usage Sophistication as defined by Blili et al. (1996). Alternatively, a more specific measure that could be used was to seek detailed information covering each application being used in terms of the number of user activities it covers, duration of use and frequency of use.

Using Kagan's Sophistication Index instrument, an Application Sophistication Index score was calculated for all firms in the sample based on the EUC application code. A variable, KASI (for Kagan's Application Sophistication Index) was created to store the value. Since the EUCSI should consist of 3 constructs as defined previously, unweighted End-User Sophistication and Usage Sophistication scores were added to Application Sophistication (KASI) to give a prototype EUCSI value. A variable, PEUCSI was created to store the value in the sample database. This becomes the Dependent Variable (DV) for the stepwise regression procedure. Note that not all Kagan's 12 IT products matched the list of EUC applications. Two IT products, *Pricing* and *Fixed Asset*, were not found in the EUC Application list. Hence the DV (PEUCSI) was based on 10 IT products plus 2 variables each from End-User Sophistication and Usage Sophistication.

The 13 EUC applications identified from the survey together with the two End-User Typology and Number of Users variables (ie. the 15-item EUC variables) were tested to identify the predictors to Kagan's original index (PEUCSI). This was done by performing stepwise regression using the survey data on all the 15-item EUC variables against the DV (PEUCSI). The idea was to predict which of the 15 EUC variables (independent variables) that best fit the prototype EUCSI (dependent variable, PEUCSI). Variables that fail to fall along the data points that form a linear relationship between the dependent and independent variables at a pre-defined significant level will be removed by the stepwise regression procedure. Using the appropriate statistical analysis as will be explained later, the new EUC Sophistication ranking was found to be consistent with Kagan, and therefore was used to measure the new EUCSI for the firms in the sample. It also integrated the two new constructs, End-User Sophistication and Usage Sophistication, which could not have otherwise been included in the index.

The regression analysis found 12 variables to be significant at the 0.001 level. As with the operationalisation of ITSI discussed in the preceding section, the Unstandardised Beta Coefficients (Regression Coefficients) produced by the regression analysis were also used as the new weighted scores. Table 5.25 includes the result of the regression analysis on the EUC variables along with the coefficients, p value and the corresponding Kagan's software checklist.

Table 5.25 EUC Sophistication Variables

EUC Construct/ Applications	Unstandardised Beta Coefficient	Significance (p value)	Kagan's Checklist
Application Sophistication			
1. EUC Word Processing application	1.525	0.001	3
2. EUC Mailing application	-0.002	0.812	
3. EUC Account/Finance	3.466	0.001	3
4. EUC Graphics application	-0.005	0.643	
5. EUC Spreadsheet application	3.994	0.001	
6. EUC Sales/Purchase Order	3.245	0.001	3
7. EUC Production Operation	0.005	0.632	3
8. EUC Personnel application	4.179	0.001	
9. EUC Stock/Inventory Control	4.890	0.001	3
10. EUC Customer Data	3.811	0.001	3
11. EUC Telecommunication	6.075	0.001	3
12. EUC Database Application	6.176	0.001	3
13. EUC Decision Model	7.863	0.001	3
			3
End-User Sophistication			
1. End-User Typology	0.979	0.001	
Usage Sophistication			
1. Number of Users	1.085	0.001	

Note: Items in ***bold*** are significant at the 0.001 level.

The 12 EUC variables (in bold letters above) became the variables used in the re-calibrated EUC sophistication index. All Application Sophistication variables found to be significant in the regression analysis are similar to the Kagan's software checklist. This may suggest that there seems to be little changes in terms of the types of applications used by end-users in the small firms in the last 10 years. This could also be the reason for the popularity of developing such applications for the fact that they are useful to small business. The regression procedure excluded Mailing, Graphics and Production Operation applications since they were not significant even at the 0.05 level. The two variables, End-User Typology and Number of Users are included and were found to be significant predictors for the re-calibrated EUC sophistication index.

Table 5.26 below shows the weighted scores and ranking between the re-calibrated and Kagan's mean scores. Note that for the sake of comparison, only those software/EUC applications that appear in both the scores are included in the table.

Comparing the weighted scores between the re-calibrated scores and Kagan's mean scores, most of the re-calibrated scores are in agreement with Kagan's mean scores. However, two EUC applications, Order Processing and Customer Services differ most significantly with the corresponding Kagan's scores compared to the other applications in the list. The rest of the scores differ only slightly and are approximately equivalent in weight. The overall ranking also appears to be approximately the same.

Table 5.26 EUC Sophistication Score Ranking

Kagan's Score			Re-calibrated Score		
Rank	Software	Weighted Score	Rank	EUC application	Weighted Score
1	Word Processing	1.65	1	Word Processing	1.525
2	Accounting & Finance	3.26	2	Order Processing	3.245
3	Order Processing	4.03	3	Accounting & Finance	3.466
4	Spreadsheet	4.03	4	Customer Services (Data)	3.811
5	Employee/Personnel	4.19	5	Spreadsheet	3.994
6	Inventory Control	4.64	6	Employee/Personnel	4.179
7	Data Applic. (Customer)	5.16	7	Inventory Control	4.890
8	Telecommunication	5.74	8	Telecommunication	6.075
9	Database	6.13	9	Database	6.176
10	Decision Model	7.83	10	Decision Model	7.863

As expected Word Processing applications was ranked the least sophisticated. As previously discussed in Section 5.1.3 Word Processing applications involve the creation and maintenance of simple documents such as form letters, quotes, mail shots, manuals and contracts. The simplicity of developing these applications has also made it possible for other less sophisticated end-users such as the administrative and clerical staff to develop these applications.

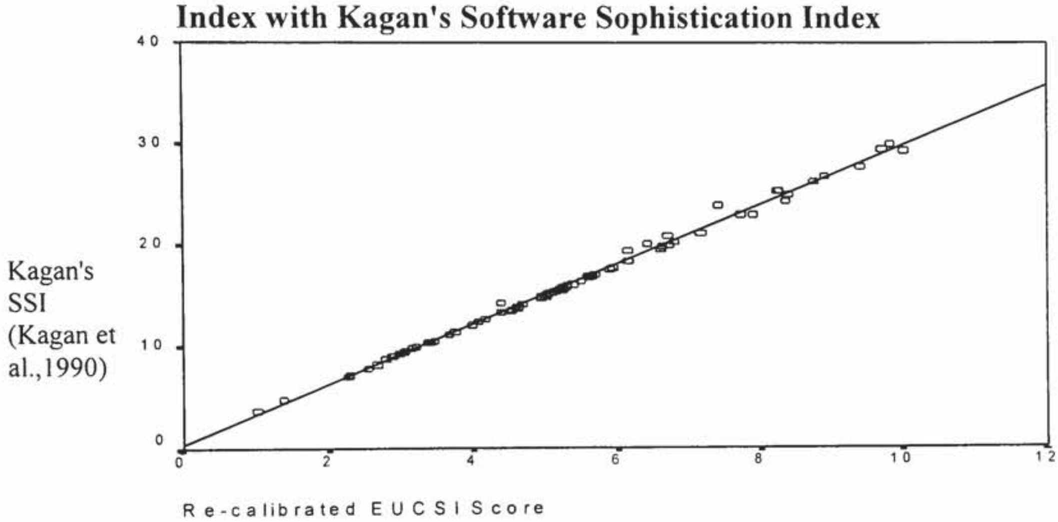
The next lowest ranked application is Order Processing, which also carries less weighted score than the corresponding Kagan's mean score. This re-emphasises the earlier discussion in the preceding section that suggests the automation of order processing in small firms involve simple data entry to capture customer order and printing of order receipts. Such automation would involve simple development work that can be carried out by less sophisticated end-users. Customer Services application was also ranked much lower (fourth lowest compared to fourth highest in Kagan's list) with the most difference in their weighted scores. This may suggests that the level of sophistication of both applications be viewed from different perspectives with the one in the Kagan's list viewed as general DP applications. Since customer information is important to businesses, capturing of customer data could be the minimum task that can be developed in a Customer Services application. This is supported by the moderately lower rank of the Customer Services application that may involve the capturing of customer data where a fairly simple data entry application can be developed. On the other hand, the moderately higher ranking of the Data Applications (Customer) as in the Kagan's list may involve fairly sophisticated processing of customer data such as maintenance of customer ratings, customer credits and other DP activities. Other EUC applications were ranked and rated consistently with that of Kagan's and together with the statistical analysis presented next, suggest the reliability of the re-calibrated scores.

Using the EUC Sophistication Score Ranking of Table 5.26, the reliability of the re-calibrated score can also be determined by performing the Spearman's Rho Rank-Order Correlation, similar to determining the reliability of the re-calibrated IT Sophistication Score discussed in the preceding section. Rankings from both Kagan's and the re-calibrated lists are fitted into the Spearman's Rho formula. Result of the Spearman's Rho Correlation produces a coefficient of 0.879 at the 0.001 level of significant. This means a strong relationship exists between the Kagan's score and the re-calibrated EUC application score ranking suggesting consistency between the two scores. This therefore suggests that the re-calibrated EUC sophistication scores are reliable and therefore represent good predictors of the opinions of the IT experts with a high level of confidence.

As with the ITSI construct discussed in the preceding section, validity of the EUCSI construct can also be obtained by correlating the results of the Kagan's SSI construct (applied to end-user developed applications only) with that derived from the re-calibrated EUCSI construct. A strong relationship should exist with a correlation coefficient close to ± 1.0 for the EUCSI construct to be valid. The Bivariate Pearson Product Moment Correlation Coefficient was used to test the relationship between the two constructs. However, before this test can be done both the re-calibrated EUCSI and Kagan's SSI were computed for all firms in the sample. Kagan's SSI computation was described previously in Section 2.5 whilst the details of the re-calibrated EUCSI formulation will be discussed later in this section.

The result of the Pearson Correlation test indicates a strong relationship exists with coefficient of 0.998 at the 0.01 level of significant. A scatterplot is drawn to visualise the linear regression that best fits the data points between the re-calibrated EUCSI and the original Kagan's SSI as presented in Figure 5.2 below. A strong relationship is apparent as the data points cluster close to the straight line passing through the data as shown in the figure. This proves that the re-calibrated EUCSI can make a good prediction of the original Kagan's index and therefore are used as the measurement for EUCSI in this study.

Figure 5.2. Scatterplot of re-calibrated EUC Sophistication Index with Kagan's Software Sophistication Index



EUC Sophistication Index (EUCSI) can now be computed by calculating the total weighted score of all corresponding EUC applications used by the firm (listed in Table 5.26) plus the two Unstandardised Beta Coefficients for End-User Typology and Number of Users (Table 5.25). The following technique similar to the IT Sophistication Score Construction described in the preceding section was used with slight modification to cater for the two additional sophistication constructs:

$$\text{Total Weighted Score} = \sum_{i=1}^{n} (\text{weighted score for application i}) * \delta_i$$
$$+$$
$$(\text{End-User Typology} * \text{Unstd. Beta Coefficient for End-User Typology})$$
$$+$$
$$(\text{Number of Users} * \text{Unstd. Beta Coefficient for Number of Users})$$

Where δ_i = 1 if the firm uses application i
= 0 otherwise
n = total number of applications

Note that the Total Weighted Score above consists of three parameters that correspond to the three sophistication constructs. The above formula therefore can be simplified as follows:

Total Weighted Score = Sum of Weighted Scores for Application Sophistication
+
End-User Sophistication Score
+
Usage Sophistication Score

The Total Weighted Score above is the raw form of EUCSI and need to be transformed so that its value falls within the range 1 to 10. The aim is to obtain a sophistication index similar to the original scale so that the same interpretation on the level of the firm's EUC sophistication can be applied. That is, an EUCSI of 1 is rated as the least sophisticated and 10 is rated as the most sophisticated among the sample firms. The following is the formula for the EUCSI transformation:

EUCSI = (Total Weighted Score + a) / b

Where a and b are chosen such that $1 < \text{EUCSI} < 10$
and $10 = (max + a) / b$
$1 = (min + a) / b$

Where *max* is the maximum Total Weighted Score of a firm in the sample and *min* is the minimum Total Weighted Score of a firm in the sample.

In order to demonstrate how an EUCSI of a firm is calculated using the above Sophistication Score Construction formula, consider a firm that uses the following hypothetical EUC applications:

Word Processing, Spreadsheet, Sales Order.
End-User Typology = 2 (command-level end-user)
Total User = 91

The following steps are carried out to calculate each of the sophistication score based on the simplified formula above:

Step 1: Compute the Sum of Weighted Scores for the firm's Application Sophistication

Sum of Weighted Scores = $\sum_{i=1}^{n}$ (weighted score for application i) * δ_i

= (**Weighted Score for Word Processing** * 1) + (**Weighted Score for Order Processing** * 1) + (Weighted Score for Accounting/Finance * 0) + (Weighted Score for Customer Services * 0) + (**Weighted Score for Spreadsheet** * 1) + (Weighted Score for Employee/Personnel * 0) + (Weighted Score for Inventory Control * 0) + (Weighted Score for Telecommunication * 0) + (Weighted Score for Database * 0) + (Weighted Score for Decision Model * 0)

Note: To aid readability, applications used by the firm are shown in bold in this example.

Substituting the weighted scores using the unstandardised coefficients of Table 5.25,

Sum of Weighted Scores = (1.525 * 1) + (3.245 * 1) + (3.466 * 0) + (3.811 * 0) + (3.994 * 1) + (4.179 * 0) + (4.890 * 0) + (6.075 * 0) + (6.176 * 0) + (7.863 * 0)
= 1.525 + 3.245 + 3.994
Sum of Weighted Scores = 8.764

Step 2: Compute the End-User Sophistication Score

End-User Sophistication Score = End-User Typology * Unstd. Beta Coefficient for End-User Typology
Substituting the End-User Typology of the firm and the unstandardised coefficient of End-User Typology as in Table 5.25,
End-User Sophistication Score = 1.958 (2 * 0.979)

Step 3: Compute the Usage Sophistication Score

Recall that the Usage Sophistication Score would require the actual value for the number of end-users in the firm to be transformed so that its value falls within the range 1 to 10. The same transformation technique can be used here and assuming that all values for total users in each firm are known so that $min = 1$ and $max = 100$ (ie. the smallest number of end-user for a firm in the sample is 1 and the largest is 100). So,

Number of User Score = (Total User + a) / b

Where a and b are chosen by solving the following equations:
$10b = max + a = 100 + a$
$b = min + a = 1 + a$

Hence, $a = 10$ and $b = 11$

Substituting the formula above,
Number of User Score = (91 + 10) / 11
= 9.182

Substituting the Number of User Score and its corresponding unstandardised coefficient as in Table 5.25 into the following formula:

Usage Sophistication Score = Number of User Score * Unstd. Coefficient for Number of Users
= 9.182 * 1.085
= 9.963

Therefore Total Weighted Score = Sum of Weighted Scores + End-User Sophistication Score + Usage Sophistication Score
= 8.764 + 1.958 + 9.963

Total Weighted Score = 20.685

Before the firm's EUCSI can be calculated, Total Weighted scores for all firms in the sample will have to be calculated using similar steps above. This will allow the transformation formula to be computed since the minimum and maximum Total Weighted scores will also be known. Assuming that all the Total Weighted scores of the firms in the sample have been computed where $min = 3.59$ and $max = 29.54$ (again as in the ITSI computation, these are actual *min* and *max* values based on the sample in this study), EUCSI for the firm in this example is computed as follows:

EUCSI = (Total Weighted Score + a) / b

Where a and b are chosen by solving the following equations:
$10b = max + a = 29.54 + a$
$b = \min + a = 3.59 + a$

Hence, $a = -0.710$ and $b = 2.883$

Substituting the EUCSI formula above,
EUCSI = (20.685 - 0.710) / 2.883
= 6.929

In the above example, the firm's level of EUC sophistication is said to be moderately high. Even though the firm developed fewer and less sophisticated applications but because the applications are used by large number of end-users, the Usage Sophistication component has influenced the overall level of EUC sophistication. This is acceptable as the more users there are the more frequent applications tend to be used and the longer the duration of usage. Blili et al. (1996) suggest that firms can achieve a high level of EUC sophistication with more frequent use of their applications over longer periods of time.

To summarise the operationalisation of the IT and EUC sophistication variables discussed in this section, Table 5.27 below shows the re-calibrated IT and EUC scores along with Kagan's original score.

Table 5.27. Re-calibrated IT and EUC Sophistication Scores with Kagan's Score

Kagan's Score		Re-calibrated IT Score		Re-calibrated EUC Score	
Software	Weighted Score	IT Product	Weighted Score*	Application	Weighted Score*
Word Processing	1.65	Purchase Order Processing	1.159	Word Processing	1.525
Accounting & Finance	3.26	Sales Order Processing	2.287	Order Processing	3.245
Spreadsheet	4.03	EDI	2.727	Accounting & Fin.	3.466
Order Processing	4.03	DSS	3.330	Customer Services	3.811
Pricing	4.08	Accounting & Finance	3.908	Spreadsheet	3.994
Employee/Personnel	4.19	Inventory Control	4.394	Employee/Personnel	4.179
Inventory Control	4.64	Employee/Personnel	4.427	Inventory Control	4.890
Fixed Asset (Branch Inv)	4.75	Internet	4.688	Telecommunication	6.075
Data Applications	5.16	Pricing (invoice and billing)	4.819	Database	6.176
Telecommunication	5.74	Fixed Asset	4.869	Decision Model	7.863
Database	6.13	Spreadsheet	4.902		
Decision Model	7.83	Customer Services	5.058		
		Database	5.785	End-User Typology	0.979
		Decision Model	7.898	No. of End-Users	1.085

* All coefficients are significant at the 0.001 level.

With operationalisation of the research variables presented in Section 4.7 and the operationalisation of the Sophistication Index presented in this section, relationships between variables defined in the research hypotheses of Section 4.6 can now be tested. The next section presents results of the hypothesis tests using appropriate measures of statistical significance to identify those factors affecting EUC Sophistication in small business.

5.3. TESTS OF SIGNIFICANCE

Statistical tests were carried out on the sample data to determine the relationships and tests the underlying hypotheses as described previously based on the initial model of Figure 3.12. Correlation analysis and Chi-square-based measures were employed as measures of association and hypothesis testing. Statistical software, SPSS for Windows Release 8 was used to carry out the tests. Results of the tests were presented and modifications were made to the initial model in the form of a revised model of EUC Sophistication in small business.

Operationalisation of the research variables as represented in the initial research model was done by examining the strengths of each relationship. A strong relationship between two variables suggests that the variables are closely related and have a high degree of association. Though the significance and strength of a relationship provides no evidence of cause and effect, formulation of the hypotheses derived from the initial model may form the basis of causation. This is considered appropriate since the initial model has been developed based on prior studies.

According to Emory and Cooper (1991, p. 582) relationships between two or more variables can be measured by using techniques appropriate to the measurement scales used. The authors suggest the most popular and regularly used techniques are Chi-square based measures and correlation coefficients. These techniques were employed using the SPSS software and a number of relationships have been identified as being statistically significant at the 0.01 or 0.05 level. Tables 5.28 and 5.29 below show the results of the Pearson's correlation and Chi-square tests on the variables being investigated. Variables that are measured on the interval and ratio scales use the Pearson's Correlation Coefficient (Emory and Cooper, 1991 p. 583) and the result is tabulated in the Correlation Matrix as shown in Table 5.28. For nominal data, 2 types of Chi-square based measures were used, Phi coefficient for 2 X 2 tables (Emory and Cooper, 1991 p. 608) and Cramer's V coefficient for larger tables (Emory and Cooper, 1991 p. 609). Ordinal scale data uses Spearman's rho correlation for the measure of association (Emory and Cooper, 1991 p. 617). Table 5.29 shows the correlation matrix for the nominal and ordinal data. In each case the appropriate measures of statistical significance have been used to identify those associations which are unlikely to have occurred by chance and may be considered to cause the rejection of the null hypotheses and no-associations. Such associations are referred to as "*correlation is significant at the 0.01 (0.05 or 0.10) level*" as shown at the bottom of Table 5.29.

Results from the tables show that IT sophistication is positively correlated with the size of the business, the number of *systems* in use, the *technology* being adopted, and the number of computerised *applications* at the significant level of 0.01. Studies on IT adoption in small business have shown that the size of the business is important and tends to determine the use of IT in small business (Raymond 1987, Kagan et al. 1990, Lai 1994, Palvia et al. 1994). Computerised applications have also been related to IS success in small firms (Magal and Lewis 1995, Palvia et al. 1994). However, Kagan et al. (1990) did not find any correlation between IT intensive and the level of IT sophistication in small business. The strong correlation between IT sophistication and *systems*, *technology* and *application* suggests that technology adoption in small business is related to the level of IT sophistication. In addition, there is also a weak negative correlation with *IT plan* at the 0.05 level of significance. The fact that the coefficient is negative may suggest that firms with less IT products they planned to acquire tend to be more sophisticated in their use of IT.

Table 5.28. Pearson Correlation Matrix for Interval Scaled Data

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ITSI								
EUCSI	.002							
Size (Staff)	.325**	.009						
Sales Turnover	.187*	-.041	.286**					
Age of business	-.023	-.017	.055	.006				
Systems	.583**	.212*	.335**	.173*	.004			
Technology	.420**	.340**	.318**	.246**	.042	.462**		
Application	.785**	-.059	.312**	.165*	.013	.455**	.325**	
IT Plan	-.245*	-.111	.075	.059	.121	-.362**	-.219**	-.094

Table 5.29. Coefficient Matrix for Nominal and Ordinal Data

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ITSI category								
EUCSI category	-.089							
CEO Interest (Support)	.152	.113						
CEO Qualification	-.191	.038	.415*					
Location	.156	.089	.014	.241				
Attitude towards EUC	.094	.085	n/a[1]	.278	.014			
Interest in EUC	.171+	.245+	.145	.203	.043	.139+		
EUC Satisfaction	.125	.012	.208	.120	.097	.182	.101	
EUC Presence	.066	n/a[1]	.186+	.293	-.049	.236**	.119	.190
[1]See footnote below								

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

+ Correlation is significant at the 0.10 level (2-tailed)

For EUC sophistication, positive correlation exists with the number of *systems* in use and *technology* being adopted at the significant level of 0.05 and 0.01, respectively. However, no significant correlation exists with EUC Satisfaction. But, evidence of a weak relationship exists with interest in EUC at a higher significant level of 0.10. *Systems* and *technology* are particularly related here perhaps because they are precursors to EUC. Without end-user development tools such as spreadsheets, word processors, databases, desktop publishing systems etc., there could be no EUC.

Behavioural issues such as attitude and interest have been studied in connection with EUC success (Rivard and Huff 1988) and IS success (Amoroso and Cheney 1992). In this study there are evidence of weak relationships between interest in EUC and EUC and IT sophistication, and relationship between attitude towards EUC and interest in EUC at the 0.10 level of significance. Attitude towards EUC is also related to the presence of EUC.

As expected, this study found no significant relationship between EUC sophistication and IT sophistication. This suggests that IT and EUC Sophistication are independent of each other. Hence a firm with high level of IT sophistication may have high (or low) EUC sophistication, and vice-versa. There is also no evidence to suggest that CEO interest (support) for EUC and CEO qualifications are related to EUC sophistication. Both variables may be related to IS/IT adoption as in DeLone (1988) and Thong et al. (1996). But the CEO's contributions towards making EUC more

[1]No measures of association are computed because at least one variable is a constant

sophisticated are perhaps less important than their support to encourage the presence of EUC as shown from the positive correlation between CEO Interest and EUC presence.

Correlation with other variables is also worth noting. Size of business, both in terms of number of staff and sales turnover, is positively correlated with the number of *systems*, *technology* and *applications* at the 0.01 and 0.05 levels of significance. Among the technology adoption factors, *system* is positively correlated with *technology* and *application*, and its correlation coefficient with *IT plan* is negative. Similarly *technology* is positively correlated with *application* and have a negative correlation coefficient with *IT plan*. It may be argued that *systems*, *technology* and *applications* are inter-related as they make up the foundation of IT. An increase in one may have an impact on the other. For example, a new system, say a group decision support system, would require additional technology such as a local area network and video conferencing facilities. New applications may certainly be added to enhance the new system, which perhaps may trigger the creation of new database systems. These relationships may continue as the firm adds more systems, technology and/or application. However, each time an IT product is added, the number of IT products planned tends to be less. Therefore, as the firm gets more sophisticated in its use of IT as evident from the increase in its *system*, *technology* and *applications*, its shopping list for IT products becomes shorter. This is consistent with the negative correlation coefficient of *IT plan* described earlier. In supporting this argument, one should note the specificity of small business in which there are limits to the acquisition of IT given the other characteristics such as limited financial and human resources remain constant.

5.4. DISCUSSION OF RESULTS

The results provide support for most of the research hypotheses defined earlier in section 4.6 of Chapter 4. These hypotheses are summarised in Table 5.30 and the rejected hypotheses are summarised in Table 5.31. This section discusses the results of the hypothesis tests following the statistical tests described in the preceding section.

Table 5.30. Summary of Hypotheses Supported

Hypothesis	Coeff	Sig. (p-value)
Hypothesis 1: Top Management Support of EUC		
H_{13}: *CEO Interest* is positively related to EUC presence.	0.186	0.068^{+}
Hypothesis 2: Organisational Characteristics		
H_{24}: Size of employee is positively related to IT Sophistication.	0.325	0.001**
H_{26}: Sales turnover is positively related to IT Sophistication.	0.187	0.025^{+}
Hypotheses 3: Technology Adoption		
H_{31}: *Systems* is positively related to EUC Sophistication.	0.212	0.050**
H_{32}: *Systems* is positively related to IT Sophistication.	0.583	0.001**
H_{33}: *Technology* is positively related to EUC Sophistication.	0.340	0.001**
H_{34}: *Technology* is positively related to IT Sophistication.	0.420	0.001**
H_{36}: *Application* is positively related to IT Sophistication.	0.785	0.001**
H_{38}: *IT Plan* is negatively related to IT Sophistication.	-0.245	0.013*
Hypothesis 4: Behavior towards EUC		
H_{42}: *User Attitude* is positively related to EUC Presence.	0.236	0.002**
H_{44}: *User Interest* is positively related to EUC Sophistication.	0.245	0.076^{+}
Hypothesis 5: IT Sophistication is independent of EUC Sophistication and EUC Presence.		
H_{51}: No relationship exists between IT Sophistication and EUC Sophistication.	0.002	0.988
H_{52}: No relationship exists between IT Sophistication and EUC Presence.	0.066	0.665

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed)

+ Correlation is significant at the 0.10 level (2-tailed)

Table 5.31. Summary of Hypotheses Rejected

Hypothesis	Coeff	Sig. (p-value)
Hypothesis 1: Top Management Support of EUC		
H_{11}: *CEO Interest* (support) is positively related to EUC Sophistication.	0.113	0.764
H_{12}: *CEO Qualification* is positively related to EUC Sophistication.	0.038	0.879
Hypothesis 2: Organisational Characteristics		
H_{21}: Location affects EUC Sophistication.	0.089	0.713
H_{22}: Location affects IT Sophistication.	0.156	0.103
H_{23}: Size of employee is positively related to EUC Sophistication.	0.009	0.939
H_{25}: Sales turnover is positively related to EUC Sophistication.	-0.041	0.742
H_{27}: Age of business is positively related to EUC Sophistication.	-0.017	0.877
H_{28}: Age of business is positively related to IT Sophistication.	-0.023	0.759
Hypotheses 3: Technology Adoption		
H_{35}: *Application* is positively related to EUC Sophistication.	-0.059	0.593
H_{37}: *IT Plan* is negatively related to EUC Sophistication.	-0.111	0.427
Hypothesis 4: Behavior towards EUC		
H_{41}: *User Attitude* is positively related to EUC Sophistication.	0.085	0.768
H_{43}: *User Attitude* is positively related to EUC Satisfaction.	0.182	0.491
H_{45}: *User Interest* is positively related to EUC Presence.	0.119	0.105
H_{46}: *User Interest* is positively related to EUC Satisfaction.	0.101	0.833
Hypothesis 6: EUC Sophistication is related to EUC Satisfaction.		
H_{61}: EUC Sophistication is positively related to EUC Satisfaction.	0.012	0.940

Hypothesis 1: Top Management Support of EUC influences the level of EUC sophistication and the presence of EUC in small firms.

The results suggest no evidence to claim that top management support influences the level of EUC sophistication in small firms. This therefore did not support hypotheses H_{11} and H_{12}, that is *CEO Interest* and *CEO Qualification* may not contribute to increased level of EUC sophistication. However, the result indicates that *CEO Interest* influences the presence of EUC, thus supporting part of hypothesis 1 (H_{13}), that is:

H_{13}: The greater the CEO interest in EUC, the greater the chance that EUC will be present.

Even though *CEO Interest* is not related to EUC Sophistication the fact that its relationship with *EUC Presence* is significant suggests that top management support for EUC is still important in influencing the existence of EUC in the small firm. Further CEO support to influence the level of EUC Sophistication may not be necessary for several reasons. Firstly, emphasis on EUC may not even be in the minds of these CEOs because the concept of EUC is relatively new in the small business environment. More education and knowledge in EUC would be needed. Secondly, these CEOs may be more concerned with the adoption of IT in the business than with IT sophistication itself, let alone EUC sophistication. Thirdly, some CEOs did not even know what an application is as suggested in half of the sample data, thus to expect them to be interested in developing one would be unreasonable.

Hypothesis 2: Organisational characteristics determine the levels of EUC sophistication and IT sophistication of the small firms.

In terms of organisational characteristics, 2 hypotheses have been supported. Size of business, both in terms of employee and sales turnover, contributes to IT Sophistication. Hence the following hypotheses have been supported:

H_{24}: Firms with more employees tend to have higher levels of IT sophistication.

H_{26}: Firms with higher sales turnover tend to have higher levels of IT sophistication.

The result however indicate IT Sophistication is not affected by age of business, thus hypothesis H_{28} was rejected. However, a weak relationship exists between location and IT Sophistication at the 0.103 level of significance (H_{22}).

Though most of these results are consistent with other studies on IT adoption and IS success in small business, they did not provide support for EUC Sophistication. In fact none of the organisational characteristics appeared to affect EUC Sophistication directly. Hence, EUC sophistication is not directly affected by where the business is located (H_{21}), the number of employees (H_{23}), sales turnover (H_{25}), and age of business (H_{27}). This may well mean that higher level of EUC sophistication can exist in small firms with very few employees, unlike IT sophistication. This conclusion however could not be generalised to include other organisational characteristics that have not been studied but may appear to have significant impact in other studies.

Hypothesis 3: Technology Adoption contributes to the levels of EUC sophistication and IT sophistication of the small firms.

Technology adoption seems to be the main factor influencing both IT sophistication and EUC sophistication in small firms, thus supporting hypothesis 3. Specifically, IT Sophistication is determined by the number of *systems* in use (H_{32}), the *technology* supported (H_{34}), the number of computerised *applications* (H_{36}), and the number of IT products planned (H_{38}). Increases in the number of *systems*, *technology* and *applications* imply a greater level of IT sophistication of the small firm. This is an important finding for EUC because as Kagan et al. (1990) suggest the need for users to develop applications increases as the level of IT sophistication increases. This is further substantiated through hypothesis H_{31} and hypothesis H_{33} that singled out *systems* and *technology* as the factors contributing to EUC sophistication. The following are the hypotheses supported for Technology Adoption:

H_{31}: The greater the number of *systems* the higher the levels of EUC Sophistication.

H_{32}: The greater the number of *systems* the higher the levels of IT Sophistication.

H_{33}: The greater the use/range of *technology* the higher the levels of EUC Sophistication.

H_{34}: The greater the use/range of *technology* the higher the levels of IT Sophistication.

H_{36}: The greater the number of *applications* in use the higher the levels of IT Sophistication.

H_{38}: The lesser the number of IT products planned to be acquired (*IT Plan*) the higher the levels of IT Sophistication.

Though the *application* variable is important for IT sophistication, it does not contribute to EUC sophistication, thus there is no evidence to support H_{35}. In fact the negative coefficient (-0.059) attributed to *application* though not significant may imply that an increase in the number of applications may actually discourage the development of end-user application. *IT Plan* is another variable whose relationship is not significant with EUC Sophistication. Its negative coefficient (-0.111) though not significant is consistent with the initial hypothesis that suggest as firms get more sophisticated in their EUC more systems and IT products tend to be put in place. This would make them to plan and acquire less IT products. Despite the lack of evidence to support both *application* and *IT Plan*, what is more important is the appropriate technology must be put in place to encourage EUC and this study has identified *systems* and *technology* as contributing to EUC sophistication.

Hypothesis 4: Behavior towards EUC influences the level of EUC sophistication, EUC presence and EUC satisfaction in the small firms.

Another important factor contributing to EUC sophistication is user's behaviour towards EUC as described in hypothesis 4. Specifically there is evidence to suggest that as *users' interests* in EUC increase, the level of EUC sophistication also increase (H_{44}). This clearly indicates that interest in EUC is an important determinant for increased EUC sophistication in the small firm. However, no direct relationship exists between *User Attitude* towards EUC and EUC Sophistication as suggested by hypothesis H_{41}. An interesting observation is that *User Attitude* is linked to *User Interest* in EUC suggesting that attitude may be indirectly related to EUC Sophistication. This is further substantiated by the support found for hypothesis H_{42}, which suggests that *User Attitude* influence the presence of EUC in the small firm. Hence the supported hypotheses for EUC behavior are:

H_{42}: *User Attitude* towards EUC influences the presence of EUC.

H_{44}: *User Interest* in EUC influences the levels of EUC Sophistication.

The rejected hypotheses, apart from H_{41} as described above include H_{43} (*User Attitude* with EUC Satisfaction), H_{45} (*User Interest* with EUC Presence), and H_{46} (*User Interest* with EUC Satisfaction). Whilst the relationship between *User Attitude* and *EUC Presence* is significant as suggested in H_{42}, a weak relationship exists between *User Interest* and *EUC Presence* (H_{45}) at the 0.105 level of significance. This may suggest that whilst a positive user attitude is required to encourage the presence of EUC in small firms, their willingness to be involved in developing applications may have some influence over the firm to embark on EUC. However, for those firms already on EUC, this involvement by end-users could actually increase the level of EUC sophistication as suggested by H_{44}.

The results also suggest that there is no evidence to link both *User Attitude* and *User Interest* with *EUC Satisfaction* as in H_{43} and H_{46}. This means that user satisfaction with the applications they themselves developed is not influence by their behavior towards EUC.

Hypothesis 5: IT sophistication is independent of EUC sophistication and EUC presence in the small firms.

The fact that EUC Sophistication is not associated with IT Sophistication confirms hypothesis 5. This implies that small firms need not wait until they have reached certain levels of IT sophistication to embark on EUC. As has been suggested at the beginning, embarking on EUC only requires a minimum investment in IT. With the same initial investment and some interest in EUC, a small firm can increase its level of EUC sophistication without the corresponding increase in IT sophistication. Hence the following null hypothesis is supported:

H_{51}: There is no evidence to support the existence of a significant relationship between IT sophistication and EUC sophistication in small firms.

Similarly, the result also suggests that there is no evidence to associate IT sophistication with *EUC Presence*. This simply means EUC could be present in firms with any level of IT sophistication. The null hypothesis supported is:

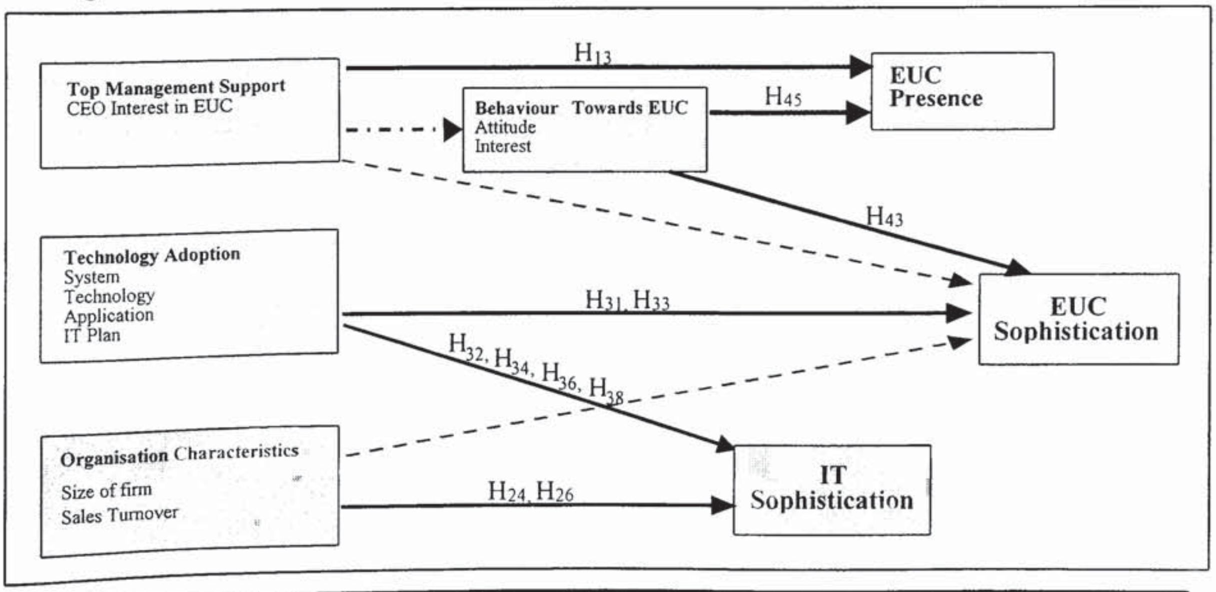
H_{52}: There is no evidence to support the existence of a significant relationship between IT sophistication and the presence of EUC sophistication in small firms.

Hypothesis 6: EUC sophistication is related to EUC satisfaction.
Finally, the result indicates no significant relationship exists between EUC Sophistication and EUC Satisfaction. Hence hypothesis 6 is not supported and the result contradicts the finding made by Zinatelli et al. (1996) who found that EUC Sophistication was also an intermediary variable contributing to EUC Success. This lacked of a significant relationship suggests that the extent to which end-users are capable of developing their applications, the complexity of the applications developed, and the degree of usage have no effect on end-user satisfaction with the applications they themselves developed.

5.5. REVISED MODEL OF END-USER COMPUTING SOPHISTICATION IN SMALL BUSINESS

Results of this study are summarised in the form of a Revised Model of EUC Sophistication in Small Firms as shown in Figure 5.3 below. Based on the empirical evidence presented in this study, EUC and IT Sophistication and their associated relationships are presented as solid lines and broken lines. Solid lines represent hard evidence as confirmed by the hypothesis tests. Broken (dash) lines suggest findings may indicate potential relationships but not found to be conclusive. Dash dot line is a link that could not be established in this study because of the structure of the data. Further research would be required to examine these relationships.

Figure 5.3. Revised Model of EUC Sophistication in Small Firms



Factors that directly affect EUC Sophistication were Behavior and Technology Adoption, whilst Top Management Support and Behavior affect the presence of EUC. IT Sophistication was affected by Technology Adoption and Organisational Characteristics. There was no evidence to relate IT Sophistication with EUC Sophistication, thus the null hypothesis was accepted. Organisational Characteristics (Location) may also affect EUC Sophistication but their relationship was weak, thus the result may not be conclusive.

The results however did not support three main hypotheses - Top Management Support with EUC Sophistication, Behavior with EUC Satisfaction, and EUC Sophistication with EUC Satisfaction. Top Management Support, both in terms of CEO Interest and Qualification was not related to EUC Sophistication. This may suggest that top management of small firms have less significant role to play in promoting increased sophistication of EUC. This contradicts prior studies on IT adoption and IS success that shows the importance of top management in supporting technology assimilation within the firm. However, in light of the significant relationship found between top management support and EUC Presence, it may be more important for top management to encourage the presence of EUC than to increase the complexity of user-developed applications, degree of usage, and sophistication of end-users. With limited financial resources, technical expertise and technology adoption management in small business would be more concern with the survival of the business and having the right people and technology in place.

Two other hypotheses rejected concern EUC Satisfaction. Behavior, both in terms of *User Attitude* and *User Interest*, was not found to be related to EUC Satisfaction. These contradict previous findings that found significant relationship between attitude and user information satisfaction. Earlier in the preceding section it was found that there was evidence to suggest Behavior, both in terms of *User Attitude* and *User interest*, affects EUC Presence and EUC Sophistication. This means that whilst increased EUC Presence and EUC Sophistication would require positive behavior towards EUC, this may not necessarily contribute to increased EUC satisfaction. This is further substantiated in the result of the other hypothesis that found no significant relationship exists between EUC Sophistication and EUC Satisfaction. Though this relationship has not been tested previously, there was evidence to suggest the EUC Sophistication affect EUC Success in small firms (Zinatelli et al., 1996).

This study has examined the effects of top management support, organisational characteristics, technology adoption, and end-user behaviour on both EUC and IT sophistication in small firms. Particularly interesting is the suggestion supported by the statistical analysis that IT and EUC sophistication are independent of each other. This study has indeed increased our understanding of the EUC phenomenon within the small business. Attempts to explain how EUC sophistication in small firms is informed by technology adoption in relation to IT sophistication have been met with success.

EUC Sophistication is not all about technology. It's construct encompassed not only technology in the form of application sophistication, but also technical capability of individual end-user (end-user sophistication), and the degree in which user-developed applications are used by other users within the firm (usage sophistication). These dimensions are included in the measures of EUC Sophistication used in this study. On the basis of this construct, a fairly complex technological relationship exists. More studies need to be done to clarify some of these relationships. For example, the very fact that application sophistication is part of EUC sophistication makes the hypothesis associated with the number of applications inconclusive. Furthermore, the end product of EUC is an application; therefore one would expect that as the level of EUC sophistication increases, the number of applications should also increase. However, empirically this is not the case, in fact, early indication shows the contrary. Perhaps this is an indication that most EUC activities tend to focus on enhancing and adding value to existing applications rather than developing new ones.

This study is not intended to provide a complete construct of EUC sophistication in small firms. Organisational issues such as extra-organisational and inter-organisational issues should also be investigated in relation to EUC sophistication. Issues of education and training, quality and risks associated with EUC sophistication should also be explored. More studies need to be done in this field to clarify much of the ambiguity that surrounds EUC sophistication in the small firms.

Following the surveys a case study was carried out to understand the EUC phenomenon in its natural context (the small firms) particularly in relation to issues that relate to EUC Sophistication. The next chapter describes the case study investigation of two small manufacturing firms in the West Midlands. The study provided hindsight on how EUC is currently being practised in these firms and how issues that relate to EUC sophistication contributed to viable strategies for EUC implementation. The Revised Model of Figure 5.3 will be used as a guideline to aid in the case study investigation where information contained in the model will then be matched against the evidence emerged from the case study analysis.

Results of the survey research should assist small firms to adopt EUC as an alternative IT adoption, and in the process, achieving optimal use of their IT resources. The benefits from this is enormous as EUC can moderate the effect of the high demand for application development as more individuals with varied skills and multi-disciplinary background can meet this demand, thereby overcoming the long-term shortage of IT skills particularly in the small firm environment.

CHAPTER 6: CASE STUDY INVESTIGATION OF BRITANNIA HEAT TRANSFER AND UNIVERSAL STEEL TUBE

6.0. INTRODUCTION TO THE CASE STUDY

In Chapter 4 of this thesis the overall research design has been discussed which saw the research being carried out in two main stages. The first stage involved a survey research where its analysis and results have been presented in Chapter 5. The second case study stage will be discussed in the present chapter and its analysis and results will be presented in the following chapter. Two major deliverables of the survey research have facilitated the case study investigation and helped ensure its successful completion. Firstly the formulation of the sophistication indexes for both IT and EUC sophistication helped identify suitable candidates to participate in the case study investigation. The two firms chosen, Britannia Heat Transfer Limited and Universal Steel Tube Company Limited, met the criteria from the perspectives of similarity within the context of EUC sophistication and differences within the context of IT sophistication. The second deliverable of the survey research is the Revised Model of EUC Sophistication that helped guide the case study investigation. The model has also helped to formulate the case study proposition and assisted in the analysis of the case study results.

The remainder of this chapter will discuss the investigation of the two firms by presenting preliminary information to the investigation, fact-finding techniques used during the investigation, and analysis of the two firms after the investigation was conducted. Preliminary information includes computation of the sophistication indexes on the two firms based on data recorded in their survey questionnaire, list of research activities performed on the two firms and summary of interview appointments held with the respective respondents. A description of the Information Engineering approach is presented which forms the major fact-finding technique used in the investigation. This approach has enabled the creation of the research database and helped in the preparation of the IT Research reports for the two firms. Cases for both firms were analysed based on information extracted from the research database and the IT Research reports. Copies of the reports for the two firms are included in Appendix 4 and Appendix 5.

6.1. PRELIMINARY INFORMATION TO THE INVESTIGATION

As previously explained in section 4.5 a minimum of two firms was required to sufficiently deal with the laborious tasks of data gathering and analysis but more importantly to come up with meaningful results. Four firms were approached from the list of the survey respondents representing different levels of EUC and IT sophistication. Three firms agreed to participate but one of the firms did not practice end-user application development, hence was not included in the study. Data collection and analyses were done on the remaining two firms and their cases are presented in this chapter.

Two firms involving two separate case studies are sufficient to meet the minimum requirement for this study. According to Yin (1994, p. 45), the number of cases in multiple case studies should not be mistaken as similar to the number of respondents in a survey. In other words, one should not think in terms of sampling logic but rather replication logic. Replication, according to the author (p. 50) is the degree of certainty required for the case study results to be significant. That is, the higher the degree of certainty required, the more replications are needed. Therefore the two firms are sufficient in order to provide the replications necessary to satisfy the minimum certainty required to analyse the results with some degree of confidence. If used in conjunction with the survey research strategy (or other research strategies) the consequence of having two firms with mixed research strategies (in this case the survey and case study research strategies) would give the advantage of cross-validation of findings through triangulation as suggested by Cavaye (1996). In this case the same if not better degree of certainty and confidence can be achieved, particularly if both strategies produce consistent results.

Both firms, Britannia Heat Transfer Limited and Universal Steel Tube Company Limited, were chosen based on their levels of IT sophistication and EUC sophistication using the sophistication indexes described in Chapter 5. On the basis of the information gathered from the survey and presented in Table 6.1, sophistication indexes for both firms are computed as follows:

<u>Computation of IT Sophistication Index for Britannia and Universal Steel</u>

Using the transformation formula described in Chapter 5 (section 5.2.2), Sophistication Index (SI) is calculated as follows:

SI = (Total Weighted Score + a) / b

Table 6.1. Relevant Information used in the computation of the Sophistication Indexes

IT Product/Application	Britannia		Universal Steel	
	IT Score	EUC Score	IT Score	EUC Score
Purchase Order Processing	1.159		0.000	
Sales Order Processing	2.287	3.245	0.000	3.245
EDI	0.000		0.000	
DSS	0.000		0.000	
Accounting & Finance	3.908	0.000	3.908	0.000
Inventory Control	4.394	0.000	4.394	0.000
Employee/Personnel	4.427	0.000	0.000	0.000
Internet	4.688		0.000	
Pricing (invoice and billing)	4.819		4.819	
Fixed Asset	4.869		0.000	
Spreadsheet	4.902	3.994	4.902	3.994
Customer Services	5.058	0.000	0.000	3.811
Database	5.785	6.176	5.785	6.176
Decision Model	7.898	0.000	0.000	0.000
Word Processing		1.525		1.525
Telecommunication		0.000		0.000
End-User Typology		2.937		2.937
No. of End-Users		4.405		2.159
Total:	54.194	22.282	23.808	23.847

**Scores are based on unstandardised beta from Multiple Regression. A zero score indicates application not used by the firm. Blanks mean item not included in computation.*

Where a and b are chosen by solving the following equations:
10b = max + a
b = min + a
From the sample, min = 7.35 and max = 56.92

Hence, a = -1.840 and b = 5.508.

Substituting the SI formula above, ITSI scores for both firms are computed as follows:

ITSI for Britannia = (54.194 + -1.840) / 5.508 = 9.51
ITSI for Universal Steel = (23.808 - 1.840) / 5.508 = 3.99

Computation of EUC Sophistication Index for Britannia and Universal Steel

Using the transformation formula described in section 5.2.3, SI = (Total Weighted Score + a) / b

From the sample, min = 3.59 and max = 29.54

Hence, a = -0.710 and b = 2.883.

Substituting the SI formula above, EUCSI scores for both firms are computed as follows:

EUCSI for Britannia = (22.282 - 0.710) / 2.883 = 7.48
EUCSI for Universal Steel = (23.847 - 0.710) / 2.883 = 8.03

From the above scores it could clearly be seen that Britannia has a high IT sophistication index with a score of 9.51 in a range between 1 to 10. Table 6.2 shows the sample Means, Percentiles and Standard Deviations of both IT and EUC Sophistication indexes. Britannia's IT Sophistication Index occupies the upper 75th percentile. This indicates that Britannia is among the top in the sample in terms of adopting IT. However Universal Steel scored below the average for IT sophistication (mean = 5.96) and with an ITSI of 3.99 it occupies the bottom 25% of the sample. This indicates that the firm has relatively low adoption of IT.

Table 6.2. Means, Percentiles and Standard Deviations of ITSI and EUCSI of the sample

	N	Mean	Std. Dev.	Skewness	Percentiles		
					25th	50th	75th
ITSI	186	5.96	2.23	-0.39	4.46	6.31	7.74
EUCSI	86	5.15	2.03	0.50	3.47	5.07	6.17

In terms of EUC sophistication, both firms registered above average EUCSI (mean = 5.15). This suggests that both firms are moderately sophisticated in their end-user application development. It is interesting to note that whilst Britannia has high levels of both IT and EUC sophistication indexes, Universal Steel has a combination of low IT and high EUC sophistication indexes. This is consistent with the earlier hypothesis that IT sophistication is independent of EUC sophistication. It is on the basis of these differences and similarities that these two firms were approached for the case study investigation.

The primary data gathering technique used was through semi-structured interviews whilst other sources of evidence used include fieldnotes, walk-throughs, reviews, company documents, direct observations and participation observations. To ensure accuracy and completeness of information all interviews were recorded and transcribed and copies of the transcripts returned to the interviewees for reviews. A total of 15 interviews were carried out in both firms each lasting between 2 to 4 hours for a duration of 3 months. A further 3 months was spent for data transcription, walk-throughs and reviews, and another 2 months for analysis and preparation of the firm's IS Strategy reports. In total the case study has taken 8 months to complete in addition to writing a computer program for affinity clustering as part of analysing the firm's strategic information. Affinity analysis is part of the requirements in the Information Engineering methodology that will be discussed later.

Activities involved in the case study investigation were planned and agreed upon by both the firms and the investigator. A list of the activities is included in Appendix 7, which shows the actual investigation began in April with the first interview and ended in December when the IT Research reports were submitted to the respective firms. The case study started with a "kick-off" meeting held with the top management of each firm. The aims were to gain the top management support and commitment to the case study project and to get initial information regarding the firm. Apart from the company's documents and brochures, information was also obtained through the company's briefing and a tour of its business operations. During the kick-off meeting prior to conducting the interview the investigator was introduced to the firm and the respondents who participated in the investigation. Everyone was told of the aims of the research, what would be involved during the investigation, and what questions and issues would be deliberated upon. In addition a contact person was identified to facilitate communications and other administrative matters throughout the duration of the study. The contact person also acted as the main informant for the study.

The overall method for conducting the case study was discussed in Chapter 4 and summarised in the form of a Case Study Research Framework of Figure 4.4. The interviewing stages for the two firms ran concurrently with a tight interview schedule to minimise as much disruption to the business as possible. Appendix 8 summarised the interview appointments held with the two firms during the course of the investigation. Interviews were held with key staff to identify the firm's business strategy. The CEO, functional directors and departmental managers were involved to explain the company's mission, business goals and functional areas. They were also asked to identify their respective critical success factors, critical problems, critical decisions and information needs. IT inventory was also recorded which include existing hardware, software, storage capacity and networking requirements. Main users who are involved in developing applications were also interviewed for information on EUC activities. All interviews were guided by semi-structured, open-ended questions and were recorded. Samples of these questionnaires are included in Appendix 3. Interview recordings were transcribed to text and reviewed by the respective interviewees. The reviewed text were then analysed along with other information from fieldnotes and observations and these were then synthesised into categories of data that made up the research database as shown in Figure 4.3. IS strategy data was then extracted from the database using the Information Engineering techniques such as Functional Decomposition, Process Modelling, Data Modelling, Association Matrices, Affinity Analysis and Entity Clustering to analyse the IS strategy of the firm. Walk-throughs were done with the main end-users on the process and data models before further analysis was carried out. An IS Strategy report was produced for each firm to mark the end of the firm's participation and commitment to the research project. A copy of each report is included in Appendix 4 and Appendix 5.

As shown in the activity schedule of Appendix 7, problems were encountered that threatened the successful completion of the case study. A substantial amount of time was spent on transcribing the interview recordings to text and getting feedback from the reviewed text. At one point the project experienced disruption causing long delays due to the difficulty of getting appointments for reviews and walk-throughs. The delays appeared to have affected the motivation of some of the respondents who could not make themselves available for meetings. As a result there were instances when meetings and tele-conversations had to be held with the contact person acting on the respondent's behalf. Under this circumstance it was thought necessary for someone to be available to continue with the investigation in order to ensure the successful completion of the case study. In this case information sought was only to clarify on what had transpired previously and no new evidence or major changes done to the original interview in order to minimise bias.

6.2. FACT-FINDING: THE INFORMATION ENGINEERING APPROACH

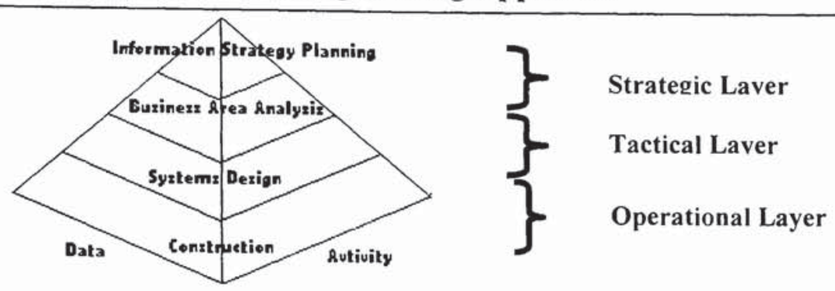
The major fact-finding technique used in the investigation follows a structured development approach known as Information Engineering. Using a well-known and proven approach this not only helped to facilitate the fact-finding process but also validated the process itself. This is important in any research study just as it is important to validate a survey instrument prior to conducting the actual survey to ensure accuracy and reliability of the data gathered. The Information Engineering approach described in this section is based on a seminal work by James Martin, the co-founder of Information Engineering together with Clive Finkelstein, published by Savant Institute (Martin, 1986a). As defined by James Martin Information Engineering is:

> *An interlocking set of formal techniques in which enterprise models, data models, and process models are built up in a comprehensive knowledge base and are used to create and maintain data processing systems.*

Clearly a complete approach to Information Engineering would require the use of automated tools such as the Integrated Computer-Aided Software Engineering (I-CASE) tool to capture the massive amount of information represented by the enterprise, data and process models as suggested in the definition above. However since the aim of the study is not to create or maintain data processing systems, but rather to deliver a high-level information requirements of the enterprise, an I-CASE tool is not necessary. Furthermore it would be economically infeasible currently for small firms to acquire such an expensive piece of software though it would help particularly in the documentation and presentation of the models and analysis of the business areas. In the case of this study, the absence of the CASE tool was compensated by developing an automated tool to create an entity-clustering algorithm as part of the Information Engineering requirement. Discussion of the algorithm will appear later in this section.

The Information Engineering approach could be illustrated using the popular Pyramid Model defined by Anthony (1965) as shown in Figure 6.1 below. Anthony's management pyramid consists of three layers or management hierarchy: Strategic, Tactical and Operational. The Strategic layer is associated with the top management of the firm and the Tactical and Operational layers are concerned with the middle and lower levels of the management, respectively. The pyramid model can be adapted to the Information Engineering approach by associating the three layers to the four stages of Information Engineering. The four stages are (1) *Information Strategy Planning* as applied to the enterprise as a whole or to a subset of it in which an information architecture is built based on a high level function model and data model; (2) *Business Area Analysis* in which the enterprise data model and process model are built for each business area; (3) *Systems Design* that establishes a detailed logical and physical design of an application for a given business area; and (4) *Construction* in which the designed application is implemented and integrated with the other applications within and outside the business area.

Figure 6.1. The Information Engineering Approach



Source: Adopted from Martin, 1986a

Figure 6.1 illustrates the top-down nature of Information Engineering involving both data and activities on the left and right faces of the pyramid, respectively. Information Engineering begins at the Strategic layer by conducting an Information Strategy Planning to the entire enterprise or certain major segment of the enterprise. Information Strategy Planning is concerned with the enterprise mission, the top management goals and critical success factors. It is concerned with how technology can be used to support the business and create new opportunities for competitive advantages. Information Strategy Planning delivers a high-level overview of the enterprise, its functions, data, and information needs.

The Information Strategy Plan maps the functional areas of the enterprise and produces a high level model of the enterprise, its departments, functions, and data. It creates an overview of the data subject and maps the corresponding entity types to the functions of the enterprise. At the Information Strategy Planning stage two types of studies are carried out and are used extensively in the case study investigation. (1) A study to review the business strategy plan in order to determine the goals, critical success factors and information needs of the different parts of the enterprise. This also includes the potential use of new technology to support the goals and create new business opportunities. (2) A study to create an overview model of the enterprise aligned to the business strategy. This is done by examining the goals, critical success factors and information needs of each function and transforms them into process and data models which will later be used to cluster groups of common entity types to similar processes appropriate for business area analysis. As mentioned previously, in the case of the case study investigation the first study was modified to incorporate a study of the actual business strategy instead of reviewing the business strategy itself. This was done because both firms did not have a formal business plan as expected in typical small businesses.

The Tactical layer covers the Business Area Analysis and part of the Systems Design, which is the logical design of systems. The Business Area Analysis emerged from the Information Strategy Plan where all business areas for the enterprise are defined. Each business area contains a portfolio of applications that will be selected for detailed system design. Business area analysis attempts to identify and define groups of interrelated processes and the data needed to form business applications in order to run the selected business area. In this stage the higher-level data subjects are decomposed into entity types where a fully normalised data model is developed in the logical design stage. Similarly the functions identified in the first stage are also decomposed into processes where a process model is developed using Process Decomposition and Data Flow diagrams. A matrix is then built to identify and determine what data entities are created, read, updated and deleted through what processes.

An Affinity Analysis is then performed on the matrix to cluster closely coupled entities based on their associations with the corresponding processes. A relationship between a process and an entity exists if the process uses the entity in its execution. These relationships are recorded in the associated matrix and constitute the input to the Entity Clustering Algorithm, which is the automated tool used to perform the Affinity Analysis. A copy of the source program written in Ada is included in Appendix 9. The algorithm computes Affinity Factors, which represents the proportion of the number of processes using a pair of entities out of the number of processes using one element of the pair (Martin, 1986b).

For example let E_1, E_2 ,E_3 ,...., E_m be the entities and P_1 , P_2 , P_3 , ...,P_n be the processes in the M-by-N matrix. The Entity Clustering program can examine every process and calculates (1) the number of processes using a given entity E_l, say; (2) the number of processes using the entity pair E_l and E_k where k is between 1 and m inclusive and $k \neq l$. Hence, let

$P(E_l)$ = number of processes using entity E_l.
$P(E_l, E_k)$ = number of processes using both entities E_l and E_k.

The Affinity Factor E_l to E_k = $\frac{P(E_l, E_k)}{P(E_l)}$

If the two entities, E_l and E_k, are never used together for the same process then their affinity will be zero. On the other hand if they are always used together for every process then their affinity will be 1. The Affinity Factor is computed for every entity in the matrix and the result is stored in an M-by-M matrix containing the 'm' number of entities.

Entities with high Affinity Factors will be grouped together to form an entity cluster. This is repeated for all combinations of entities in the matrix resulting in several clusters of entities. In order to ensure consistency in the result, combinations of different threshold values are applied by the program to examine the movement of entities among the clusters in order to identify the best patterns that fit these entities. Among the thresholds used include (1) a minimum Affinity Factor needed to create a new cluster; (2) a minimum Affinity Factor of the symmetric entity pair needed to include an entity in an existing cluster; (3) a minimum Affinity Factor needed to add an entity to a present cluster; and (4) a minimum Affinity Factor needed to include an entity in the analysis. A value of 1 (ie. 100%) tends to create as many clusters as they are entities. If on the other hand the value of the Affinity Factor is 0%, then there will be only one big cluster containing all the entities. The idea is to use combinations of different Affinity Factors among the different thresholds and let the program determine the number of clusters by exhaustively examining the entities. These clusters are then reviewed for similarity in their characteristics to form groups representing potential business areas where business applications can be identified.

Results of this analysis a lead to the creation of an application portfolio where the business applications are grouped into four categories representing four priority areas. These are (1) *Strategic*; (2) *Operational* or *Factory*; (3) *Potential* or *Turn-around*; and (4) *Support*. *Strategic* applications are those that are critical to the current and future success of the business. Businesses whose applications fall within this category depend upon IT for their competitive position. Applications that are closely related to supporting the company's mission and goals belong to this category.

Applications in the *Operational* category are those that are important in supporting the day-to-day business activities. Though their presence is critical in support of the current business, their importance is not expected to remain in the future. Contrary to this are applications in the *Potential* category where businesses they support are expected to use IT in the future in order to remain competitive. Hence applications in this category tend to move to the *Strategic* category depending on the availability of technology and computing resources. Applications that belong to the *Support* category are not essential to achieve competitiveness but their presence can ease the business operation and facilitate and improve the management information and activities of the business area.

Figure 6.2 shows the four categories of the application portfolio adapted from McFarlan and McKenney's Strategic Importance Matrix (1983).

Figure 6.2. Application Portfolio for a Business Area

Strategic Importance of Planned Applications		High (Strategic Importance of Current Application)	Low (Strategic Importance of Current Application)
	High	**Strategic**	**Potential**
	Low	**Operational**	**Support**

Adapted from McFarlan and McKenney (1983)

The bottom part of the pyramid is the Operational layer that covers the physical Systems Design and Construction stages. With the Business Area Analysis completed and the logical Systems Design readily available in the "comprehensive knowledge base", the remaining Systems Design and Construction stages can proceed relatively quickly, particularly with the presence of automated design tools and prototyping. Even without an automated design tool system design and implementation can proceed using the standard structured design methodology. What is more important is the applications that are being implemented were derived from the firm's information strategy document whose plan was closely aligned with the business strategy.

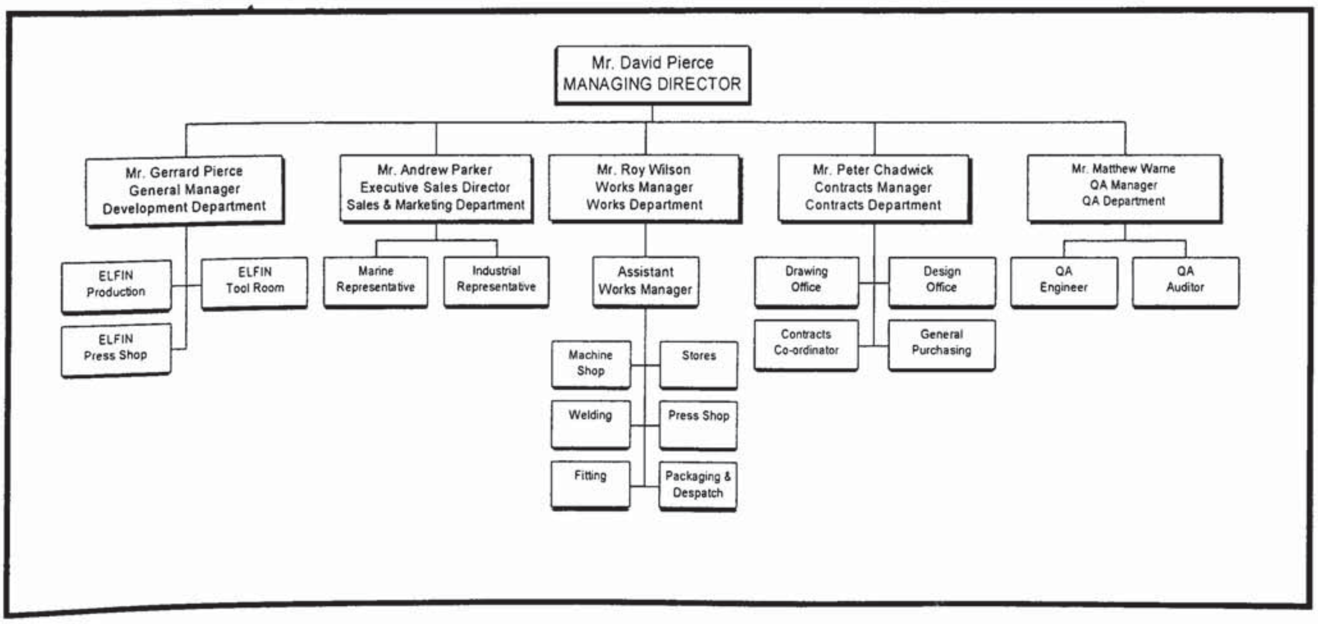
6.3. CASE STUDY OF BRITANNIA HEAT TRANSFER LIMITED

6.3.1. Company Profile

Britannia Heat Transfer Limited (Britannia) is a small manufacturing company established 10 years ago and is located in a sub-urban area of Birmingham 48 kilometres from the City Centre. Its primary business is in the design, manufacture and supply of products and components for the heat transfer industry. This include heat exchangers, coolers, condensers and tubes with sales coming from diverse markets such as power generation, petro-chemical, marine and other industrial firms both domestic and international. The firm has been registering modest profits for the past 4 to 5 years with sales ranging from £4 to £6 million per annum. It has set a 30% annual growth target for expansion.

The employment figure is 45 with 6 management staff headed by a Managing Director and supported by 5 departmental managers. The MD is also the owner of the company. The departments include the Sales and Marketing department, the Works (Production) department, the Contracts department, the Quality Assurance department, and the Development department. In addition there is also an Accounts and Administration section as part of the MD's office handled by a part-time accountant hired on a twice-weekly basis. Figure 6.3 below shows the organisation structure of the firm. Detailed discussions of the department's functions form part of the IT Research Report included in Appendix 4.

Figure 6.3. Organisation Chart of Britannia Heat Transfer Limited



6.3.2. IT Adoption

Given the IT Sophistication Index computed for Britannia as in section 6.1, the company emerged as among the top 25% of all the 186 small firms in the survey in terms of using IT. All the departments including the MD's office, administration and accounting section have access to PC's. These PC's are connected to the firm's local area network which is an Ethernet LAN technology using a $10Base_T$ UTP cabling with 10Mbps transmission rate. The network configuration uses a Bus topology with a CSMA/CD protocol for access and collision detection. There are a total of 17 PC's and a Pentium File Server that is also a communication server linked to the Internet. Britannia also maintains a web page that has proved to be an effective marketing and advertising tool. According to the MD within 3 months of publishing the company's web page over the Internet, the firm received an enquiry from abroad and later managed to secure a contract worth £½ million. The firm's web page can be found at the following location: http://www.britheat.co.uk.

In terms of IS organisation, Britannia does not have a formal IS section, neither does employ an IT professional to support its IT use. However, it is the effort of one senior member of the management that has given Britannia the level of IT sophistication it has today. This person is the General Manager of the Development department who is also the son of the owner. He is a strong advocate of IT and is seen to be the IT Champion for the firm not only encouraging others to use IT but he himself develops the business applications for the firm. The MD gives his full support for this effort, though not a computer-literate himself, but he strongly believes in what IT can give to the business.

Strong indications of the level of IT adoption can be seen from the number of applications computerised and the category the application belongs. Table 6.3 lists the applications used by Britannia showing the application category and the source of their existence. Specifications of the current hardware and software can be found in the Britannia Report included in Appendix 4.

Three applications belong to the Word Processing and Database categories, whilst five applications are in the Spreadsheet category. It is interesting to note based on

Table 6.3 below that 12 out of 13 applications were developed in-house. This indicates Britannia has a high presence of End-User Application Development.

Table 6.3. List of Applications used by Britannia

Application	Category	Source
Accounting Systems	Accounting & Finance	Package
Contracts	Word Processing	In-house
Credit Control	Spreadsheet	In-house
Customer Enquiry	Word Processing	In-house
Engineering AutoCAD	N/A	In-house
Fixed Asset	Spreadsheet/Fixed Asset	In-house
Sales Forecast	Spreadsheet/Decision Model	In-house
Invoice & Billing	Word Processing	In-house
Material Control	Spreadsheet/Inventory Control	In-house
Personnel Record	Employee/Spreadsheet	In-house
Purchase Order	Order Processing/Database	In-house (developing)
Sales Order	Order Processing/Database	In-house (developing)
Stock Control	Inventory Control/Database	In-house (developing)

6.3.3. Presence of End-User Application Development

Following the study of EUC Sophistication in the Small Business, Britannia has a high level of EUC sophistication with an index of 7.48, again within the top 25% of the sample having EUC. Various factors may have contributed to this. The presence of a strong IT Champion could be a significant factor. As described previously the GM, Development department is also the End-User Developer and is responsible for developing all the high-end category applications, specifically involving organisational information systems. As such according to Rockart and Flannery's (1983) End-User Typology, this GM can be categorised as a Functional Support End-User, that is the category of end-users with sound business knowledge capable of developing applications independently for others. A modified version of the typology for small business is presented in (Dahalin and Golder, 1998b) which categorised these end-users as End-User Developers which in addition to the above are also characterised by their capability to use a system's advanced features to create procedures and/or documents as application modules.

The GM, Development department is very much involved in the business since it was started 10 years ago. At a young age of 19 he left school to assist his father to set up the business. He has held various positions within the company from working in the workshop as a machinist, a welder, a fitter, to the accounts, contracts and sales before heading the Development department. He took an interest in IT six years ago and started experimenting with application development by reading books, IT magazines and systems manuals. He has never been to an IT training course but his knowledge of IT increased "on the job" by actively involved in application development. He was observed to have a good knowledge in Visual Basic, DataEase and Microsoft Access and has used these tools to develop applications. Currently he is developing the firm's Sales Order Processing and Purchase Order Processing (SOPPOP) Systems, which was started 3 years ago and had undergone 3 major revisions. Initially it was developed using Visual Basic but later migrated to Access, as the GM believes that Access is a powerful application development tool, easy to learn and is user-friendly.

Apart from sound business knowledge and a good development tool, the development method is also an equally important factor to ensure successful application development. The GM however lacked this third factor. One of the main IS problems identified by other end-users is the rigidity and "unfriendliness" of the system. Quoting some of the remarks made by the other managers, "...there isn't a cross-referencing .... if I want the same steel tube, I can't go to the screen and say give me a list of all suppliers.... " and "....I did exactly what the instructions said but I still don't know if it's done it. It didn't say sort of ....well done, it works, you've done it right, just carry on with your business.....". Perhaps the GM should seriously consider "user participation" in any application development projects, which clearly isn't the case at this moment.

Another problem is the GM's limited knowledge in database design. He is not aware of the importance of *normalisation* in relational database design, which has resulted in failure of the SOPPOP application to address the update and deletion anomalies. In fact this problem was realised much too late, which resulted in the third major revision with the whole SOPPOP systems re-designed from scratch. For the GM however, this problem is part of the way he learnt IT "on the job". These problems explained the apparent long delay for the applications to go live, together with the part-time nature of the task. The GM, apart from being the application developer is also the firm's GM for the Development department whose primary function is concerned with new product design and development.

The presence of EUC in Britannia has never been encouraged nor discouraged. However users are required to use the applications developed for them and they are also encouraged to use other IT facilities such as word processing and e-mail to communicate between staff. However, application development is restricted and treated with caution. Only those individuals who proved to have the knowledge and skill in end-user development are allowed to develop their own application. Currently 3 other users have the capability but are limited to word-processing and spreadsheet development. These users develop applications such as Contracts, Credit Control, Customer Inquiry, CAD drawings, Invoice and Billing, and Material Control. They can be categorised as Command Level End-Users as defined by Rockart and Flannery's End-User Typology. This group of end-users could access data through menu-driven interfaces and able to interact with the system on their own and know the systems' elementary functions to access and manipulate data and information. However, evidence also suggests that at least one of these users has a database design capability and 'secretly' developed an application. Although that has contributed to his own personal productivity (and also his department and the firm in general), no recognition was accorded for his effort.

Whilst recognising the increase in personal productivity, EUC according to the GM could also be harmful as it could lead to existence of isolated applications that could have been developed by someone else. Other limitations of EUC include duplication of data, inaccurate results due to applying the wrong formula, and too much time spent on IT tasks.

Despite these limitations it is interesting to stress that the presence of End-User Application Development is quite inevitable. The IS Strategy study conducted for Britannia identified several applications that can potentially be developed by end-users. Table 6.4 below shows the list of the strategic and the operational applications identified in the Business Area Analysis phase of the Information Strategy study. Nineteen out of a total of 44 applications have been included and identified as important in support of Britannia's business strategy and its daily operation. Out of these, only 5 applications are currently being addressed and these are in various phases of development. Three applications have been implemented, one in the design phase, and another in the analysis phase. The various phases of End-User Development Life-Cycle (EUDLC) is also shown for the current applications. For each application an end-user typology has also been identified that represents the level of End-User Sophistication capable of developing such an application.

Table 6.4. Strategic and Operational Applications for Britannia together with Phases of EUDLC and End-User Typology

Applications	(S)trategic/ (O)perational	Phases in EUDLC	End-User Typology
1) Product & Component Database Application	O	N/A	End-User Developer
2) Inventory Control & Bills Of Materials	O	Analysis	End-User Developer
3) Customer Database Application	S	*	End-User Developer
4) Customer Inquiry System	O	*	Command-Level End-User
5) Invoice Printing	O	Implemented	Command-Level End-User
6) Delivery Order Printing	O	N/A	Command-Level End-User
7) Packing Notes Printing	O	N/A	Command-Level End-User
8) Job Booking Application	O	N/A	End-User Developer
9) SOPPOP System	S	Design	End-User Developer/ IT Professional
10)Sales Forecasting	S	Implemented	Command-Level End-User
11)Pricing Application	O	Implemented	Part of Vendor's Package
12)Quotation Printing	O	N/A	Command Level End-User
13)Sales Account Maintenance	O	N/A	End-User Developer/ IT Professional
14)MRP System	S	N/A	IT Professional/ Vendor Package
15)Production Scheduling System	O	N/A	IT Professional/ Vendor Package
16)Work-in-Progress Application	O	N/A	IT Professional/ Vendor Package
17)Capacity Planning Application	O	N/A	IT Professional/ Vendor Package
18)Quality Information System	S	N/A	End-User Developer
19)Audit Information System	O	N/A	End-User Developer

*Tables created as part of other applications

A detailed breakdown of the business areas and the other applications in the Potential and Support categories are described in the IT Research Report included in Appendix 4. It is interesting to note from Table 6.4 that 63% of the applications identified in the IS Strategy study as important have neither been addressed nor planned prior to the study.

As mentioned previously Strategic applications are those applications supporting critical business areas directly related to the company's mission and business goals. Applications in the Operational category are those that support critical day-to-day business activities. Both categories are important to the business and their development should be given priority.

Out of the 3 applications implemented, one is strategic and the other 2 are operational. The SOPPOP system, which is strategic, is in the Design phase, and the Inventory Control application is in the Analysis phase. Other applications listed in Table 6.3 but are not included in Table 6.4 are comparatively less critical and belonged to other less important categories.

Interestingly, without the Information Strategy study the majority of the applications listed in Table 6.4 would not have been known and the potential for end-user application development would have been missed. This in itself suggests the importance of conducting such a study to ensure not only proper utilisation and co-ordination of IT resources but equally important to overcome the risks associated with EUC.

6.4. CASE STUDY OF UNIVERSAL STEEL TUBE COMPANY LIMITED

6.4.1. Company Profile

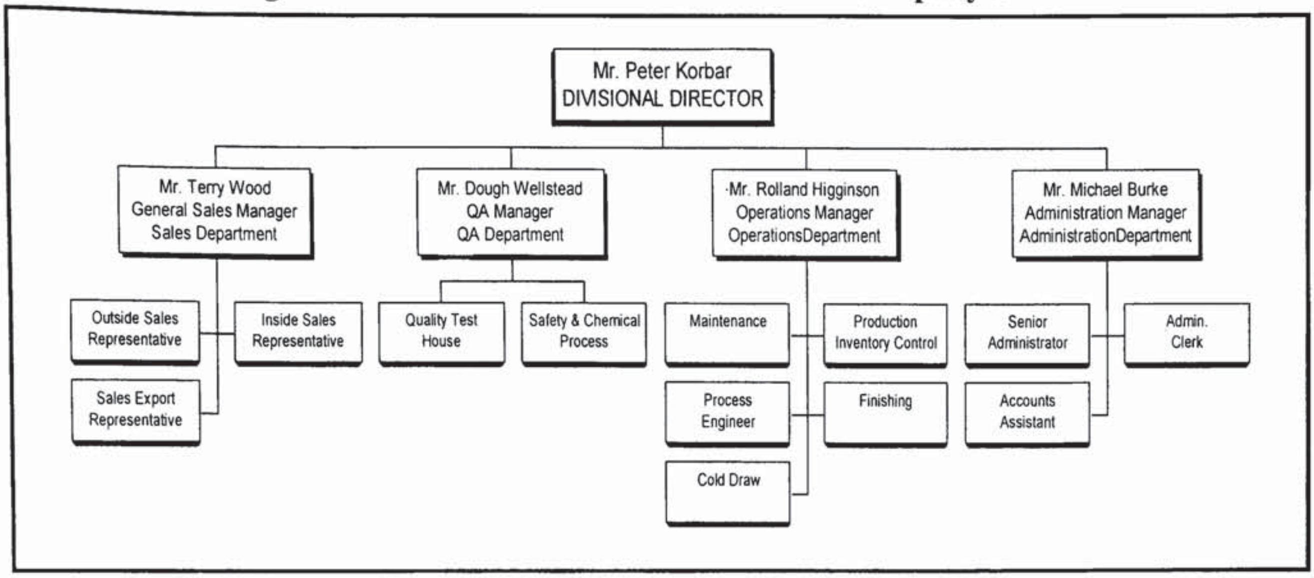
Universal Steel Tube Company Limited (Universal Steel) is a small manufacturing company established 70 years ago operating in the City of Birmingham, only 4 kilometres from the heart of the city. The firm manufactures cold drawn seamless steel tube to produce quality tubing products mainly for the domestic market. It became part of an international steel company based in the United States when the former owner sold it after experiencing huge losses during one of the worst hit depressions nearly 10 years ago. As a result more than 150 workers were made redundant to ensure its survival leaving behind just 12 people struggling to revive the company. It was not until the second redundancy programme 2 years ago and a change in the firm's business strategy with the installation of new and modern facility, machinery and equipment that the company is heading for better times, and for the first time last year managed to achieve a break-even.

Though Universal Steel has a diversified range of customers from the general engineering to the specialised industries such as the power generation, process, automotive, transport and heat transfer, it has now shifted into smaller and more specialised tubing products to capture a certain market niche. This should enable Universal Steel to add value to its products and services in order to survive by being competitive and to satisfy its customers' needs.

The firm now has a staff strength of 49 (18 full-time plus 31 contract) headed by a Regional Director who is an expatriate from the parent company. Though he has autonomy over the running of the company as an entrepreneur, decisions on major investments and strategy will have to be sought from the parent company. The Regional Director is supported by 4 departmental managers that include the Sales General Manager, the Operations Manager, the Quality Assurance Manager, and the Administration Manager. Figure 6.4 below shows the organisation chart extracted from the IT Research Report of Appendix 5. A detailed description of the departmental functions is also included in the appendix. One of the major problems faced by the firm is staff turnover with an average of one staff leaving a month.

Universal Steel has annual sales of £4.5 million and produces 5-600,000 tonnes of steel. It has a small 10% export market but aimed to increase its production by 20% of which more than half contributing to export. Universal Steel has also set a 20% annual target growth rate.

Figure 6.4. Organisation Chart of Universal Steel Tube Company Limited



6.4.2. IT Adoption

The use of IT in Universal Steel is comparatively small and less sophisticated. In the survey of 186 small firms it is within the bottom 25% with an IT Sophistication index of 3.99 as computed in section 6.1. With the exception of the Regional Director, each department has a PC and these are connected to the firm's network. The backbone is a thick Ethernet $10Base_T$ cable in a Bus topology with a CSMA/CD protocol.

There are a total of 8 PCs, 4 in the Administration department, 2 in Sales and one each in Operations and Quality Assurance. One of the PCs in Administration acts as a File Server and also a communication server for remote file transfer to the Parent Company. Financial reports and the company's sales and production figures are transmitted daily via a dial-up File Transfer Protocol (FTP). Summarised periodic reports of the company's performance are also sent monthly, quarterly, half-yearly and yearly. The firm however has no access to the Internet and no web site of its own.

As with most small firms, Universal Steel does not have a formal IS section nor an IT professional to support the adoption of IT. However one person is responsible for IT. This person is the Administration manager who manages and supports the use of IT, from acquisition of hardware and software, installation and maintenance, to end-user support, and application development. Though not an IT professional himself, he is a firm believer of IT and is considered an IT champion for Universal Steel. However, his biggest obstacle in championing IT comes from no other than his superior, the Regional Director himself!

Other members of management are receptive towards the use of IT. On the basis of the case study there is a general feeling that the firm is not doing enough in terms of IT adoption. Though IT has been present in the firm for more than 15 years, the number of business applications computerised is still small. For a number of years the existence of a couple of PCs were mainly for remote transmission of reports to the Parent Company and the use of word processing and spreadsheet for preparation of those reports. Today certain areas have more applications computerised whilst others remain largely manual. Some of the managers interviewed voiced their dissatisfaction with this and even made known their frustration for not being able to do much because they themselves are not computer-literate.

Table 6.5 below shows some indications of the level of IT adoption by Universal Steel. The table lists the applications used along with the application category and their sources. Specifications of the current hardware and software can be found in the firm's IT Report included in Appendix 5.

Table 6.5. List of Applications used by Universal Steel

Application	Category	Source
Accounting Systems	Accounting & Finance	Package
Job Planning	Database	In-house
Personnel	Employee/Database	In-house
Training	Database	In-house
Sales Order Intake	Order Processing/Database	In-house
Banking	Telecommunication	Vendor
Customer Search	Database	Vendor
Government Imports	Database	Package
Invoice and Despatch	Word Processing	In-house
Work-in-Progress	Database	In-house
Test Certificates	Word Processing	In-house
Product Analysis	Spreadsheet	In-house
Budget	Spreadsheet	In-house

It is interesting to note that most of the applications are in the Administration and the Operations business functions. This is due to the fact that the Administration manager was the Operations Manager before heading the Administration department. The Administration manager developed all the in-house database applications, and with the help of an administration clerk developed the word processing and spreadsheet applications.

Nine of the 13 applications as shown in Table 6.5 are developed in-house. Two applications each belong to the Word Processing and Spreadsheet categories, whilst seven applications belong to the Database category of which 5 were developed in-house. This indicates Universal Steel has a moderately high presence of End-User Application Development.

6.4.3. Presence of End-User Application Development

According to the study of EUC Sophistication in the Small Business, Universal Steel has a moderately high level of EUC sophistication with an index of 8.03 within the top 25% of the 86 small firms having EUC. As described previously the presence of a strong IT Champion could be a contributing factor. The Administration manager is the sole End-User Developer and he is responsible for developing most of the applications. Being an Administration manager he has also the authority to instruct his staff to develop smaller and much simpler applications and he could directly supervise and guide the tasks with his experience and knowledge in both IT and the business.

Using Rockart and Flannery's (1983) End-User Typology, the Administration manager can be categorised as a Functional Support End-User similar to Britannia's GM, Development department. He is the only long surviving member of the management team having 20 years experience in the company. He has a technical degree in engineering and has worked in various capacities from the Workshop to the Sales, back to the Workshop (Operations) and then the Administration. His interest in IT developed through his fascination at what IT can offer, particularly automating mundane and repetitive tasks. Through his vast experience in the business he was able to identify bottlenecks in certain processes and decided to automate them.

The Administration manager's awareness in IT increased through attending seminars and presentations by vendors, as well as reading books and magazines. With his seniority and influence in the company he managed to convince the management to purchase a Database Management software, DataEase which according to him is easy to use and user-friendly. The purchase includes an intensive training in database design and application development. He had his first taste of application development when he subsequently developed the Sales Order Intake that includes the automatic printing of invoices and delivery notes. Thereafter, for the next 3-4 years he helped developed a few more applications as was shown in Table 6.5. However, the development activity came to a halt more than a year ago and has not resumed since due to heavy losses incurred 2 years ago. This has forced the firm to make another redundancy programme which resulted in shortage of people. The Administration manager was asked to concentrate entirely on administrative work in order to cope with the workload. His responsibility for IT is limited to maintaining the present systems without any development work. This has resulted in his knowledge and skill in application development become obsolete and deteriorated, which he himself admitted. He was hoping that the IS Strategy study could be a strong basis for him to justify his IT expansion plan not only to the Regional Director, but also to the Parent Company since now Universal Steel is picking up its business.

The Regional Director however is a bit skeptical of IT. He believed that IT would not encourage communication among staff, which is vital for a small business. In his words: "*The last thing I want is for them to set up their own little dynasties behind closed doors and their cubicles doing their own things with these PCs and not really communicate with each other*". Further, he blamed the bad staff turnover saying, "*..... that's why some of the turnover has been as dramatic as it's been, because we don't talk to each other ..... If you don't do that all the tools in the world ain't gonna help anyway*".

However, despite his skepticism the Regional Director believed that with proper study of Universal Steel's IT requirements, it would help the firm to assess its current IT position and recommend "*where we're going with our IT system*". In other words it is important that an IS Strategy study be done to assist the firm to plan for its growth and to put proper systems in place based on the firm's business strategy.

Based on the IS Strategy study conducted for Universal Steel several applications have been identified that can potentially be developed by end-users. Table 6.6 below shows the list of the strategic and the operational applications identified in the Business Area Analysis phase of the Information Strategy study. Twenty out of a total of 56 applications have been included and identified as important in support of Universal Steel's business strategy and its daily operation. Out of these, only 6

Table 6.6. Strategic and Operational Applications for Universal Steel together with Phases of EUDLC and End-User Typology

Applications	(S)trategic/ (O)perational	Phases in EUDLC	End-User Typology
1. Invoice Printing	O	Implemented	End-User Developer
2. Delivery Order and Packing Notes Printing	O	Implemented	End-User Developer
3. MRP System	S	N/A	Vendor
4. Job Booking (Planning)	O	Implemented	End-User Developer
5. Production Scheduling System	O	N/A	Package/Vendor
6. Work-in-Progress	O	Implemented	End-User Developer
7. Capacity Planning Application	O	N/A	Package/Vendor
8. Work Shift System	O	N/A	End-User Developer
9. Customer Database Application	S	*	End-User Developer
10. Enquiry System	O	N/A	Command-Level End-User
11. Credit Rating Application	O	Implemented	Vendor
12. Quality Information System	S	N/A	End-User Developer
13. Audit System	O	N/A	End-User Developer
14. Sales Order Processing	S	Implemented	End-User Developer
15. Purchase Order Processing	S	N/A	End-User Developer
16. Sales Forecasting	S	N/A	Command-Level End-User
17. Pricing Application	O	N/A	End-User Developer
18. Quotation Printing	O	N/A	Command-Level End-User
19. Account Maintenance Application	O	N/A	End-User Developer
20. Inventory Control & Bill of Material	O	N/A	End-User Developer

*Tables created as part of other applications

applications are currently being addressed. They are all in the implementation phase since no new developments of applications have been done in the last one year plus. End-user typology has also been identified that represents the level of End-User Sophistication capable of developing such applications.

Table 6.6 above shows 6 applications are in the Strategic category and the remaining 14 applications belonged to the Operational category. Only one application that has been implemented belonged to the Strategic category and 5 out of the 6 applications implemented are developed by the End-User Developer. However 11 other applications listed as "Not Applicable" (N/A) have not been addressed prior to the study. Compare this with the list of applications listed in Table 6.5, it could be seen that in addition to the 11 applications 5 of the 9 applications that are developed in-house have been identified as important and critical to the business. This shows that the majority of the applications listed in Table 6.6 would not have been known and the potential for end-user application development would have been missed.

6.5. SUMMARY OF THE CASE STUDY INVESTIGATION

This chapter has presented the case study investigation by analysing the information gathered from the two firms, Britannia Heat Transfer Limited and Universal Steel Tube Company Limited, that have volunteered to participate in the research. Based on the information gathered there are some similarities and differences between the two firms. Both firms can be categorised as 'medium' small in size with total employment in the 45 - 50 range, though Universal Steel employed more than half of its staff on contract basis. Both are manufacturing based companies coming from a family business background and have evolved into private limited companies. However Universal Steel was bought over by another family-based business in Illinois, USA but remains as an independent company headed by an expatriate owner-proxy. Britannia is still headed by the owner himself but is currently opting for management buy-out. In terms of organisation structure both firms have a rather flat structure with generally three levels, typical of small business set-up. Main departments include Sales and Marketing, Production and Quality Assurance. Whilst Administration is a major department for Universal Steel it is only a small unit in Britannia. Likewise Product Development is an integral department for Britannia but for Universal Steel it is only a function of the Production department. This can be attributed to the emphasis placed by each firm that forms part of their business strategy. Britannia's mission to strive for product excellence is a justification to create a Development department. For Universal Steel their priority is to put the business in order after years of losses and the Administration department was given the tasks of facilitating communications between the other departments in addition to providing support to the respective departments. Similarly if IT is to excel in these firms a separate department or IT unit should be created to emphasise its importance.

For IT adoption both firms are experience users of IT with more than 10 years of using IT. Both have also installed network connecting all departments with PC links to a server. While Britannia has an Internet access and maintains a website, Universal Steel has a dedicated private link to its parent company in the USA. As expected both firms have no formal IS function and no IT staff to support IT which again are typical characteristics of small firms. Responsibility for IS is given to a senior management staff who is also the firm's IT Champion as well as the main End-User Developer. In both firms the IT Champions are very experience and have sound knowledge of the business but received mixed IT knowledge and skills. Britannia's IT Champion is a self-IT enthusiast while his counterpart in Universal Steel depends more on IT training and vendor support. Both however are firm believers in in-house development and developed most of their applications themselves.

One of the main differences between the two firms with respect to IT adoption is their level of IT sophistication. As mentioned previously Britannia is one of the most sophisticated IT adopters among the 186 small firm sample while Universal Steel is among the least sophisticated firm. Evidence of this difference could be found in the number of IT products, systems and software used by these firms and the complexity of the products, systems and software used. Britannia far exceeded Universal Steel in all of these categories. Britannia has more than twice as many PCs compared to Universal Steel and Britannia's user to PC ratio is 1 compared to 3 users for every 2 PCs for Universal Steel. Likewise for other IT products Britannia has 17 compared to only 7 for Universal Steel.

In terms of End-User Computing both firms have high EUC sophistication as has been seen previously. More than three-quarter of the computerised applications was developed in-house, out of which all the organisational information systems was developed by the IT Champions themselves. It is interesting to note in the case of Universal Steel despite having a high EUC sophistication index, currently there has been an absence of EUC activities. The assumption that the study of EUC sophistication can only be done in firms with EUC presence can no longer hold as seen in this particular instance. Lessons could also be learnt in the case of Britannia in which minimal training in application development and database design should be considered to achieve better-developed systems in the shortest time possible.

Detailed analysis of the case study results is presented in the next chapter where further analysis of the cross-case results is discussed. Emphasis is placed in the observation of the research variables and their relationships discovered during the case study investigation based on the EUC Sophistication Model.

CHAPTER 7: ANALYSIS OF CASE STUDY RESULTS

7.0. ANALYSIS OF CROSS-CASE RESULTS

The previous chapter presented the analysis of the two firms, Britannia Heat Transfer Limited (Britannia) and Universal Steel Tube Company Limited (Universal Steel) that participated in the case study investigation. This chapter presents the results of the analysis based on information gathered across the two cases using the Revised Model of EUC Sophistication as the research framework. Cross-case results are tabulated based on the firms' background information, dependent variables representing the dimensions of EUC Sophistication, and the independent variables as appeared in the revised model. Results of the cross-case analysis are then used to modify the revised model and form the final deliverable of the research study.

In analysing the data presented in the two cases, evidence was examined, categorised, tabulated and recombined to address the initial propositions as described in the revised model. A pattern-matching strategy (Yin, 1994 p.106) was used to compare the data, as an empirically based pattern of evidence, with the propositions and at the same time alternative patterns of predicted values were sought. This is to ensure that the findings are based on strong internal validity of the cases and that strong causal inferences can be made to the propositions.

A cross-case analysis is presented to compare data from both firms where patterns could be established. This would enable similar or contrasting results be obtained, consistent with Yin's suggestion on literal replication and theoretical replication (Yin, 1994 p. 64). A cross-case summary of the firms' basic characteristics is presented in Table 7.1 to reiterate some of the main findings already discussed previously. Obvious similarities and differences can be seen in all three categories of the firms' Basic Profile, IT Adoption, and EUC Presence. Similarities in the Basic Profile include ownership and industry sector. Both firms are in manufacturing and are registered as Private Limited companies which represent the majority of firms in the sample. Both also have an overall above average employee size but still within the 'middle' small category. However, if full-time employment is used to measure firm size then Britannia has larger firm size than Universal. Obvious differences include Age of Business, Annual Sales Turnover and Location in which Britannia is relatively much younger than Universal Steel but has more sales and located in the rural area. Universal Steel represents the typical small business that belonged to the older generation, which tends to be located near and around the city.

Table 7.1. Summarised Background Information of Britannia and Universal and their IT Adoption and EUC Presence

Characteristics	Britannia	Universal Steel	Sample Average
I. Basic Profile			
• Ownership	• Private Limited	• Private Limited	• Private Limited (67.8%)
• Industry	• Manufacturing	• Manufacturing	• Manufacturing (54.3%)
• Age of business	• 19 years	• 68 years	• 41.8 years
• Size (staff)	• 45	• 18 (plus 31 contract)	• 43.5
• Sales (annual turnover)	• £6.0 million	• £4.5 million	• £4.55 million
• Location	• Rural	• Urban	• Urban (69.4%)
II. IT Adoption			
• Years using IT	• 3	• 15	• 9.6
• No. of PCs	• 18	• 6	• 13.8
• No. of Users	• 18	• 9	• 17.5
• IT Support	• 1	• 1	• 2.5
• No. of systems/IT products	• 10	• 3	• 5.8
• No. of applications	• 13	• 13	• 7.9
• CEO Support	• Strong	• Weak	• N/A
III. EUC Presence			
• End-User Typology	• 1 - End-User Developer 3 - Command-Level	• 1 - End-User Developer • 1 - Command-Level	• N/A • N/A
• Applications developed by end-users	• 12	• 9	• N/A
• Source of end-user support	• Self-supported	• vendor/training	• N/A
• Experience in EUC	• 4 years	• 7 years	

Some of the data presented in Table 7.1 provides support for previous studies on IT Adoption and EUC in small business, whilst other evidence may suggest the contrary. For example, the capability of small firms to develop their own applications as evidenced from the EUC presence of both firms confirms earlier studies (Raymond, 1985; Lees, 1987). The lack of support for IT as presented by the data in both the firms and the sample average is typical of many small businesses (Doukidis et al., 1996; Raymond 1990b). A strong CEO support implies an increase in IT adoption (Thong et al., 1996) where Britannia is seen to have greater use of IT compared to Universal Steel. This is supported by the pattern of evidence on the number of PCs and the number of users as well as the number of systems and IT products possessed by Britannia in relation to Universal Steel. In addition, data on EUC Presence as presented in Category III of Table 7.1 shows that in the absence of experience in application development, training can be an alternative to encourage end-users to develop applications as suggested by Raymond (1988). Conversely, this also implies that in the absence of training in application development, on-the-job experience can also become an alternative to encourage End-User Application Development as demonstrated by Britannia.

Contrasting results can also be seen based on the data presented. There is no evidence to suggest that the firms are experiencing difficulty in developing applications due to having users with low level of computer literacy as suggested by Montazemi (1987, 1988). However, difficulties have been experienced in other areas such as time constraints, limited human resources, and the firms' profitability in relation to application development. Though it was earlier reported that Britannia experienced design problems in its application development, both firms have never suggested the lack of technical knowledge as a difficulty or stumbling block to application development. The fact that both firms have a high-level of computer literacy may suggest the growing trend not only in IT adoption but also EUC in small business. In terms of EUC Sophistication the present and future look certain for increases in Command-Level End-Users and End-User Developers. This is contrary to what has been suggested by Montazemi (1987, 1988) and others (Cragg and Zinatelli, 1995) who argued that end-users in small business belonged to the non-programming or simple end-user typology.

Similarities and differences can also be found in the various phases of the End-User Development Life Cycle (EUDLC). As expected both firms did not have a formal plan for end-user development. This is not surprising considering that both firms did not even have formal IT plans and formal business plans. Development plans are very much informal and rest entirely with the main end-user developer. The planning horizon is short and involves what needs to be done in the immediate future. There were no long-term development plans in both the firms.

Analysis and design activities are carried out on a part-time basis resulted in long delays for applications to go live. In the case of Britannia the delay has been aggravated due to the lack of sufficient skills and knowledge in development methods. Whilst Universal Steel depends on training and guidance from the expert,

Table 7.2. Description of Activities in the EUDLC Phases in Britannia and Universal Steel

Phases	EUDLC	Britannia	Universal Steel
Planning	Planning for End-User Application Development	No formal EUC planning. After SOPPOP to develop Inventory Control and evaluate MRP II.	No formal EUC planning. Upgrade existing DataEase applications to Windows version.
Analysis	Analysis of End-User Tools	Suitability of tools based on compatibility with existing tools, ease of use and trialability; knowledge of tools gained on-the-job through trial and error.	Acquisition of tools based on tool performance and sales offer; criteria include ease of use and compatibility; knowledge gained through training, workshop and sales presentation.
	Analysis of End-User Applications	Work on a part-time basis; no user participation and rely on experience.	Work on a part-time basis; encouraged user participation through interviews and own experience.
Design	Conceptual Design of End-User Application	Based on personal experience, guidance from books and software own manuals; use in-depth personal knowledge/experience about process; no modeling technique used.	Received guidance from training institute to come up with conceptual design based on relational modeling; design DB structure directly from model.
	Development of End-User Application	Use MS-Access 4GL development tool to develop screen forms and menus; build prototypes to test screens and application structures; writes Visual Basic codes for Application Programming Interfaces; conduct user tests prior to implementation.	Use combination of forms and menus to build application structures using DataEase 4GL facilities; use QBE facility to generate reports and inquiries; conduct user tests before implementation.
Implementation	Operations on End-User applications	Parallel with fixed cut-over dateline; user instructions as guidelines to operate applications; no user training; no user manual/documentation on complete system; no guidelines for individual applications.	Fully on-line upon completion of data entry; no user manual/documentation to operate applications; no user training; use only verbal instructions.

Britannia relies on its experience on-the-job through trial and error. Both firms however use 4GL facilities extensively during application design and conducted user tests prior to implementation. During implementation no user training was given since it was thought that applications were simple and easy to operate. However Britannia provided written instructions as guidelines to operate the system but Universal Steel preferred verbal instructions to the end-users. Description of development activities of each firm in the various phases of the End-User Development Life Cycle (EUDLC) is summarised in Table 7.2 below.

7.1. ANALYSIS OF THE DIMENSIONS OF EUC SOPHISTICATION

As discussed earlier in this thesis, the term EUC Sophistication is used to refer to the capability of end-users to develop their own applications. Based on related studies, EUC Sophistication has three principal dimensions namely, Application Sophistication, Usage Sophistication and End-User Sophistication as suggested by Blili et al. (1996), Zinatelli et al. (1996), and Kagan et al. (1990). Based on these 3 dimensions an EUC Sophistication Index (EUCSI) was developed to measure the degree of EUC Sophistication existing in small businesses. The Index was based on the type and nature of the applications developed (Application Sophistication), the duration and number of users using the applications (Usage Sophistication), and the End-User Typology (End-User Sophistication). EUC and IT Sophistication indexes have been discussed previously and elaborated in Chapter 5 of the thesis.

A cross-case analysis of the dimensions of EUC Sophistication is tabulated in Table 7.3 below. Both firms have above average EUC Sophistication Index though Universal Steel has a slightly higher level of sophistication. It is interesting to note that whilst Britannia's EUC Sophistication index is less than it's IT Sophistication index, Universal Steel on the other hand has higher EUC Sophistication index than it's IT Sophistication index. The index suggests that both firms have a moderately high level of EUC Sophistication, which means they have the ability to develop their own application.

Table 7.3. Cross-case Analysis of the Dimensions of EUC Sophistication

	Britannia	Universal Steel
EUC Sophistication Index	7.48	8.03
Dimension		
Application Sophistication No. of Application developed Application Category	 9 (plus 3 currently developing) 3 x Word Processing 5 x Spreadsheet 3 x Database 1 x CAD	 9 2 x Word Processing 2 x Spreadsheet 5 x Database
Usage Sophistication No. of End-Users Duration of use	 18 3 years	 9 7 years
End-User Sophistication Non-Programming End-User Command-Level End-User End-User Developer	 14 3 1	 7 1 1
User Satisfaction		
Satisfaction with own application developed Satisfaction with applications developed by others	Very Satisfied Less Satisfied	Satisfied Satisfied

Examining the variables in each dimension, mixed strengths and weaknesses were identified for both firms. These could have moderated the effect of one measurement over the other and explained the closeness in the EUCSI values. For example, though Britannia has 12 applications developed (or under development) in-house compared to 9 in Universal Steel, the application category of Universal Steel shows they have more database-type applications developed than Britannia. Recall that database applications are more sophisticated than word processing and spreadsheets (Kagan et al., 1990). Similarly in the Usage Sophistication dimension Britannia has twice the number of end-users but Universal Steel has slightly more than twice the experience of using the applications. For End-User Sophistication dimension both firms have achieved the maximum typology level with one end-user application developer each. The evidence presented has demonstrated that the overall level of EUC Sophistication in both firms is moderately high and can be categorised as the same.

In terms of End-User Satisfaction, the case studies have enabled two variables to be examined. One is *End-User Satisfaction with own application developed*, and the other is *Satisfaction with applications developed by other end-users*. The pattern on own development seems to agree with the Initial Model that suggests EUC Sophistication as an intermediary factor, in which it is an antecedence of End-User Satisfaction. This suggests that the moderately high level of EUC Sophistication by both firms results in end-users being satisfied with the applications they developed. However, a rather mixed pattern exists for satisfaction with the application developed by others. This is particularly true for Britannia where the users perceived the applications they used as less than satisfaction. Since the behavior of this variable is unpredictable, the result for User Satisfaction fails to show the entire pattern as predicted. However, this is consistent with the hypothesis test that found no evidence of a significant relationship between EUC Sophistication and End-User Satisfaction.

7.2. ANALYSIS OF THE INDEPENDENT VARIABLES

The Revised Model of EUC Sophistication shown in Figure 5.3 incorporates Top Management Support, Technology Adoption, Organisational Characteristics, and Behavior towards EUC as factors contributing to EUC Sophistication in small business. As explained earlier, these factors are the results of the finding from the survey in which empirical evidence was gathered based on the series of hypothesis tests discussed in chapter 4 of the thesis. This case study attempts to make a second revision of the Revised Model by examining each of these factors based on the evidence presented.

In small firms top management plays a dominant role in the business and their support in IS projects could affect the adoption of IT in the firm (Thong, Yap and Raman, 1996). Likewise, top management support for End-User Application Development is crucial for continued presence of EUC in the firm. Evidence observed in the two cases shows differing patterns of outcome by the CEOs and other members of management in regards to top management support for end-user application development. This is evidenced by the information gathered for the two firms as summarised in Table 7.4 below.

Whilst both firms have a moderately high levels of EUC Sophistication as discussed previously, a strong CEO Support for end-user development across the two firms would have been consistent with the proposition. However, a weak CEO support in

Table 7.4. Summary of variables for Top Management Support across the two cases

Variables	Britannia	Universal Steel
CEO Support	Strong	Weak
CEO Interest	Weak	Weak
Managers' Support	Strong	Strong
Managers' Interest	Moderate	Weak

Universal Steel suggests a contrasting result but for predictable reason. As discussed previously, the CEO in Universal Steel decided not to allow end-user development activities for the last year or so as the firm was experiencing continued losses. This absence in EUC is indeed predictable for a firm with weak CEO support and therefore the contrasting pattern of evidence supported the proposition and is consistent with Yin's view of theoretical replication (Yin, 1994 p.46).

Table 7.4 above also suggests a weak CEO Interest in end-user development may not have an effect on EUC, as CEOs are too busy with the business to develop their own application. Managers may also have some influence over end-user development as they normally represent members of the top management team in a small business. Hence a strong support from the firm's managers may also indicate a strong top management support for end-user application development. This may also suggest the CEO being an entrepreneur is usually the main decision-maker but may not be as autocratic as suggested by Doukidis et al. (1996).

The second factor examined in the Revised Model is Technology Adoption, that is the use of Information Technology in small firms. Prior studies on IT Adoption and IS Success suggest Technology Adoption as one of the important factors for technology assimilation in small businesses (De Lone, 1988; Kagan et al., 1990; Magal and Lewis, 1995). According to the Revised Model, the level of IT Sophistication of a small firm is independent of the level of EUC Sophistication. However, the number of systems software and IT products used are positively related to the level of EUC Sophistication. Table 7.5 below shows a summary of the variables that make up the Technology Adoption factor observed in both firms.

Table 7.5. Summary of variables for Technology Adoption

Variables	Britannia	Universal
IT Sophistication	High (9.51)	Low (3.99)
No. of Systems & IT Products used	17	8
Computerised Applications	13	9
PC Requirement (current figure in bracket)	22 (18)	13 (8)
Application Requirement (critical in bracket)	49 (19)	51 (20)
Percentage of Applications not computerised	73%	82%

Given that the level of EUC Sophistication for both firms is moderately high, the evidence for IT Sophistication for both the firms as shown in Table 7.5 above suggests no predictable pattern exists. Britannia has high IT sophistication and generally greater IT adoption than Universal Steel. This therefore supports the proposition that both IT Sophistication and EUC Sophistication are independent of each other. More importantly it reaffirms the idea that even small firms with low IT adoption can develop their own applications as is the case for Universal Steel.

Whilst the proposition supports the relationship between the number of systems and IT products used with the level of EUC Sophistication, the pattern of evidence shows a contrasting outcome. The value of the variable for Universal Steel is unexpectedly lower when compared to Britannia for a moderately high EUC Sophistication. However, this pattern is consistent with the levels of IT Sophistication for both firms. In the light of this finding this suggests that the relationship between the number of systems and IT products used with EUC Sophistication can no longer be supported.

It should also be noted from Table 7.5 that the number of computerised applications contributes to IT Sophistication, but not EUC Sophistication. This is consistent with the previous study which suggests that EUC Sophistication may not be too concerned with the quantity of applications developed but it tends to focus on enhancing and adding value to existing applications rather than developing new ones. The significantly high percentage of applications not computerised in both firms may indicate this trend.

Table 7.5 also shows the future IT requirements (*IT Plan*) taken from the firms' IS Strategy document. Both PC and applications requirements show lesser number of IT products required in the future by Britannia compared to Universal Steel. Whilst the future PC requirement for Britannia is to be increased by 4 (ie. 22-18), the increase in PC requirement for Universal Steel is to be increased even higher (ie. 13-8=5). Similarly for application requirement since the number of current applications for both firms is the same as in Table 7.1, the increase in the planned application for Britannia is less than that of Universal Steel. This pattern of evidence is consistent with the proposition as in the Revised Model, that is the number of IT products planned is negatively related to IT Sophistication.

Organisational Characteristics is the next factor that contributes to EUC Sophistication in particular, and IT Sophistication in general. Whilst the Revised Model supports the relationship between Organisational Characteristics and IT Sophistication, there is no evidence to suggest the same relationship exists for EUC Sophistication. The 2 variables used to measure Organisational Characteristics are the Age of the firm and the Size (both in terms of the number of full-time employees and the sales turnover). Table 7.6 shows the summary of the figures for both firms together with additional organisational variables that have been observed and are of interest.

Table 7.6. Summary of variables for Organisational Characteristics

Variables	Britannia	Universal Steel
Age of firm	19 years	68 years
Size (No. of full-time employees)	45	18 (plus 31 contract)
Size (Sales Turnover)	£6.0 million	£4.5 million
Location	Rural	Urban
Profitability	£500,000	£0 (break-even)
IT/EUC Champion	Strong	Strong

Previous studies on IT/IS Adoption in small business suggest that Age, Size and Location of the firm are determinants of IT Adoption and IS Success in the small business (Raymond, 1987; Palvia, Means and Jackson, 1994). However, the patterns of evidence presented in Table 7.6 show some mixed results. Size of firm, particularly the number of full-time employees clearly support the previous studies and is consistent with the Revised Model proposition in terms of IT Sophistication and to a lesser extent EUC Sophistication. Age and Location are not supported in terms of IT Sophistication and these are also consistent with the findings in the Revised Model. For Age it was expected that the more established (older) firms tend to be more sophisticated than the younger firms, and firms within the urban area are more exposed to IT and therefore tend to be more sophisticated. However the evidence presented in Table 7.6 above shows the opposite for IT Sophistication and therefore was not supported.

The Age and Location patterns are also not consistent with EUC Sophistication as suggested in the Revised Model study. While both firms have above average EUC Sophistication index, Britannia is considered less established (younger) than Universal Steel with way below the sample average of 42 years. Britannia's rural location did not stop it from achieving a high level of EUC sophistication, as in the case of its urban counterpart. Hence these mixed patterns have failed to support the propositions that relate Age and Location to EUC Sophistication.

However, in term of size, both in terms of the number of employee and sales turnover, there exists a weak pattern of evidence. If firm size is strictly based on full-time employment then Britannia has a higher full-time employee size compared to Universal Steel and the resulting mixed pattern does not help to support the proposition. However, taking Universal Steel's overall employee size of 49 (18 full-time plus 31 contract) then both firms have approximately the same size and a consistent pattern would have been achieved. Taking the sales figure as the firm's size it appears that Britannia has higher sales than Universal Steel. This is consistent with the proposition for both IT and EUC Sophistication as indicated in the Revised Model. However since the average sample sales is £4.55 million with 5.5 standard deviation both firms seems to have approximately the same sales turnover. With this additional information the pattern of evidence between sales as a factor for firm's size and EUC Sophistication appears to be consistent across the two firms and the proposition that the firm's size is related to EUC Sophistication could have some degree of support.

Two additional organisational characteristics namely the firm's profitability and the presence of an IT Champion may have some effects on IT Sophistication and EUC Sophistication. The case studies suggest Profitability is related to IT Sophistication but may not be related to EUC Sophistication. Recall earlier that Universal Steel's successive losses in recent years had prompted the CEO to stop EUC activities altogether. However, it is interesting to note that despite the absence of EUC at present, the firm's level of EUC Sophistication remains moderately high. This suggests that EUC Sophistication itself does not preclude the presence of EUC as initially envisaged in the construction of the Revised Model.

The presence of a Champion as one of the organisational factors has been observed and identified in many IS implementation studies (Markham, 1998; Carr and Hogue, 1989). A strong Champion has been identified as a critical factor for the success of technology assimilation (Lai, 1997). The consistent pattern of a strong IT Champion across the two firms (literal replication) as shown in Table 7.6 suggests that IT Champion may also contribute to EUC Sophistication. However within the context of EUC Sophistication the IT Champion in this case is not only an influential person who manages the course of IT within the firm but also the major contributor to end-user development. Perhaps it is more appropriate to use the term "EUC Champion" in this case.

The last factor examined in the Revised Model is Behavior of End-Users towards EUC. User Attitude for instance has been recognised as an important factor influencing end-user development satisfaction (Rivard and Huff, 1988) and end-user information satisfaction (Amoroso and Cheney, 1992). This is also consistent with the Revised Model proposition that suggests User Attitude is positively related to the presence of EUC, and that another behavioral factor, User Interest is contingent on User Attitude and positively related to EUC Sophistication. Table 7.7 gives a summary of the variables observed in the cases on the Behavior of End-Users towards EUC.

Table 7.7. Summary of variables on Behavior of End-Users

Variables	Britannia	Universal Steel
End-User Attitude towards EUC	Positive	Positive
End-User Interest in application development	4 out of 18 (22%) developed applications	2 out of 9 (22%) developed applications

In the case study, End-User Attitude is taken to mean the perception of the end-users on whether it is useful for them to develop their own applications. End-User Interest is an indication of the end-user's willingness to develop their own applications and this is measured as the proportion of end-users actually developing applications. Almost all the end-users interviewed in both firms feel positive about writing simple queries and use the spreadsheet to assist their work though most of them lacked such skill. While training has been mentioned to improve skill some users are apprehensive about the prospect of not being able to use the new skill effectively for various reasons including top management directive, unclear IT policy, and time constraints. A few mentioned their anxiety on the lack of support, as no one will be around to give a helping hand if they make a mess. One manager (non-End-User) actually has a very negative attitude even towards IT and had rejected all proposals to computerise his function. He turned down a request to participate in the case study and believed he can perform better without the aid of computers, relying on his knowledge and experience.

Despite some of the negative outlook, the patterns of evidence as shown in Table 7.7 are consistent with the Revised Model proposition. A positive attitude towards EUC, though not necessarily leaves a direct influence on EUC Sophistication, but may encourage interest in application development, which in turn encourages EUC Sophistication.

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Despite having a moderately high EUC Sophistication, both firms employed different sources for application development support. Whilst training have been seen to be a popular choice, for a small business, on-the-job experience is also preferred. The case study found that on-the-job experience could be an alternative to training to encourage end-users to develop applications. Whilst a combination of training and experience would be a better option, training without experience or vice-versa could still encourage end-user development.

The case study also found that strong support from the management is essential for EUC presence and EUC Sophistication. Whilst CEO Support would contribute to the presence of EUC, the role of the middle management (Manager Support) is also vital to encourage EUC Sophistication in the small business. There is also evidence to suggest that the presence of an EUC Champion would have an impact on increased in EUC Sophistication. Based on observation from the case study, it could be suggested that in a small business an EUC Champion is also highly likely to be an IT Champion.

Finally, the case study also found consistent patterns on Behavior towards EUC in relation to EUC Presence and EUC Sophistication. Whilst a positive End-Users' attitude towards EUC would encourage the presence of EUC, it could also contribute to interest in the form of personal initiatives to actually develop their own applications. This would in turn contribute to increased EUC Sophistication.

On the basis of the accumulated evidence from the case study and results from the survey analysis, the Revised Model as presented in Figure 5.3 can now be modified to produce the final (modified) Model of EUC Sophistication in Small Business. This modified model represents the final deliverable of the research study and will be discussed in the next chapter.

CHAPTER 8. DISCUSSION

8.0. INTRODUCTION

This chapter reviews the main findings of the research as described in the previous chapters, identifies its main contributions and suggests possible future work. Findings of the survey, supported by evidence from the case study, are summarised. This is followed by discussion of the Modified Model of EUC Sophistication in Small Business, review of the sophistication indexes, and the factors that affect EUC sophistication in small business. The main research contributions are discussed highlighting the significance of the literature, contribution of the model and sophistication measurements, and the significance of the independence between IT and EUC sophistication. The contribution to research methods in IS is also discussed, followed by impact of the research, its implications for small business, limitations of the study, and possible future work.

8.1. MAIN FINDINGS OF SURVEY AND CASE STUDY

The survey and case studies provided the information needed to address the main aims of the research, that is *to study the factors contributing to EUC sophistication* and *the extent small firms are capable of developing their own applications*. This section begins with a discussion of the main findings of the survey supported by evidence from the case study investigation. Structural information in the form of a summary of the firms' demography and background information is presented. This is followed by a summary of the findings on IT adoption and EUC presence. Pertinent information from the case study investigation is also included wherever it offers insight into a particular discussion to support or contradict a particular argument.

8.1.1. Structural Information

The sample was taken from the mailing list held by the Birmingham Chamber of Commerce and Industry (BCCI) and was based on simple random selection of 1000 firms with below 100 employees. The firms' demography and background information show that the majority of the sample represents typical small business in the medium *small* category (ie. 10 to 49 employees) with an average of 43.5 employees. The micro or small *small* category (ie. less than 10 employees) is almost certainly under-represented because very small companies tend to have high rates of mobility and mortality and are unlikely to be represented amongst the BCCI membership. The findings indicate that the more established firms tend to have larger number of employees and are located nearer to the city. Both the selected case study firms show a somewhat similar pattern falling within the medium *small* category and the more established firm of the two having slightly more employees and being located within the city.

To get a feel of the type of industries represented in the sample, findings by industry reveal that the manufacturing sector dominates the sample with over half the sample size. Manufacturing firms are generally located within the city with a long history of presence compared to their rural counterparts. The case study firms were both in manufacturing. In terms of employee size, firms in the services sector have the most number of people employed whereas wholesale and retail firms have the least number of employees.

Two important findings were observed with respect to the respondent, who was the person at the company who completed the questionnaire. Firstly almost all of the respondents belonged to the middle to top level management with more than half of the respondents being top executives. This was expected as the manager or the person with the greatest responsibility for IT was asked to complete the questionnaire. Hence, as intended, results of the survey successfully represent opinions of the senior management. Secondly only a small proportion of the respondents held an IT related job despite an explicit direction to forward the questionnaire to the person responsible for IT. The fact that senior management is generally responsible for IT could mean that small firms are treating the adoption of IT very seriously despite the absence of the IT professionals. This also suggests that small firms can generally be categorised as having no formal IT function and lack of IT expertise, which are typical characteristics of small business. These findings are also reflected in the case study firms where the main respondents (informers) held senior management positions and were also responsible for IT. Equally both firms had no formal IT function and no staff with formal IT background.

8.1.2. IT Adoption and Sophistication

The questions on the firms' IT adoption found that firms in the sample are generally IT literate with the majority of the sample having at least 5 years of IT experience. However one-quarter of the sample did not have any staff to support IT. The rest would appear to support IT on a part-time basis only. This is consistent with the case study firms where the people supporting IT are also holding formal non IT positions. This suggests that small firms still regard the IT function as informal despite the general belief that IT is important to businesses.

The study found that all firms in the sample have at least one PC and the majority of the firms use networks to connect their PCs together. This finding confirms the proliferation of PCs in all businesses and suggests a surprisingly high adoption of computer networks in small business. Small firms are now realising the potential of data communication to facilitate the sharing of computer resources and the exchange of information. The study also found that the ratio of user to PC tends to be one-to-one and that one in every six staff is a user of a PC. Both the case study firms had a Local Area Network installed to facilitate data communication and sharing of computer resources.

In terms of IS provision this study found that small firms tend to prefer in-house IS provision and development compared to external sources and outsourcing. This may also suggests that external sources and outsourcing are not within the financial means of most small businesses. The specialist nature of small business could require bespoke applications to be developed and most ready-made packages might require extensive modification to meet their requirements. Both case study firms relied on in-house development for their IS applications. Among the reasons given were packages offered could not meet their business requirements, firms already have the EUC capability, and external sources are too expensive.

The questions on other IT products besides computers identified facsimiles and telephones as the other two most popular products used by the small firms. The use of modems is also significant, which suggests that most firms in the sample have a need to exchange and transfer data and information across the telecommunication network for inter-firm communications. This was also observed in the case study. A modem is used in one firm for the purpose of transmitting reports and financial data to the firm's parent company in the USA. The other firm uses the modem to access the Internet and publish its own web site.

In terms of current software usage the study found that Word Processing is the most popular software product and it is used by almost all firms in the sample. This is followed by Spreadsheet, Database, Mail Merge and the Internet. For future software requirements the Internet appears to be the most popular new product. Other products planned include Electronic Mail, EDI and CAD/CAM.

The questions on the computerisation of business processes found that Accounting and Financial systems are the most popular applications to be computerised. Three reasons can be suggested for this popularity. Firstly, the wide availability of accounting packages in the market so that users can find one that best meets their requirements. Keen competition and mass production of these packages help ensure prices are kept down and affordable by small firms. The second reason is the legal requirement that all businesses maintain proper and standard accounting records. Such standard and routine practices would help make computerisation of the Accounting and Finance application much easier. Thirdly, it has been a tradition in firms that any purchases and acquisitions are the responsibility of the Finance or Accounting department. It comes naturally then that the Finance or Accounting department will have more influence over the choice of software to buy and this may contribute to the popularity of the accounting and other financial related applications. This can also be seen from the other popular applications computerised that tend to be finance-based such as Invoice and Billing systems, Credit Control systems, Sales and Purchasing applications. In contrast, business processes that remain predominantly manual are generally non-financial, including Personnel Management, Marketing/Advertising, Contracts and Project Management.

8.1.3. EUC Presence and Sophistication

Responses to questions on EUC presence showed significant development of EUC in these small firms. Results from the survey revealed slightly more than half of the sample claimed to develop their own computing applications. Moreover, despite the criticism and scepticism of EUC expressed by almost 56% of the sample, almost half of these respondents who rejected the idea of EUC did actually indicate their interest to be involved in the EUC case study. This was true of one of the case study firms in which the CEO has been sceptical not only of EUC but also IT adoption. The CEO's remarks that computers discouraged communication among staff and caused the high staff turnover were evidence of this. However, a more serious underlying problem was the fact that this firm had incurred continuous losses over a number of years and was forced into two redundancy programmes. This resulted in a shortage of staff and the main end-user developer was directed to concentrate only on administration and to stop all development work. Because of this further EUC activities have been suspended for the last 2-3 years and no acquisitions of new hardware and software were made during this period. It was only through encouragement and influence from the other managers that the CEO indicated his interest in IT and agreed to participate in the case study investigation in order to assess the firm's IT strategy including the potential for end-user application development.

The most popular EUC tool was the Spreadsheet, followed by Word Processing and Databases. In all three categories, the Microsoft suites of products dominate the application development tools used. In the Spreadsheet category, Microsoft Excel is the top choice. For Word Processing, Microsoft Word came top, and the most popular Database tool for end-user application development is Microsoft Access. It is also interesting to note for DBMS software, non-database packages are also favoured by the end-user developer. These include Microsoft Word, Lotus 1-2-3, Microsoft Excel and Microsoft Works, which are more suited for word processing and spreadsheet development. This suggests that the applications that are developed are simple and straightforward without the complex data structure and data modelling required in a typical design of database applications. In addition this may also reflect the lack of formal IT training particularly in the database area.

The study found that the most popular applications developed using Spreadsheets are the Financial ones. Other applications developed using Spreadsheets include Order Processing, Inventory Control and Forecasting. The majority of the Spreadsheet application developers are the respondents themselves. This is also true for the Database developers but not the Word Processing developers. The fact that a large majority of the sample respondents come from the middle-top level management suggests that managerial level personnel in small firms tend to develop most of the applications using Spreadsheet and Database packages. A typical Word Processing application such as Document Maintenance is much simpler to develop and is left to other end-users who made up more than half of the Word Processing developers. For Databases, as with Spreadsheets, the most popular applications developed are Financial. This is followed by Document Maintenance, Customer Services and Inventory Control.

The findings also suggest fewer end-users tend to use applications developed with Spreadsheet and Database compared to Word Processing. This may suggest such applications tend to be more specific and tailored to individual business processes and used in small work-groups rather than organisation-wide. Financial applications, for instance, are only used by a small group of end-users in the Finance department or section as opposed to Document Maintenance or Mail Merge that can be used by most departments handling documents.

In terms of user satisfaction, the study found that end-users are generally satisfied with the applications they used that were developed by other end-users. This is also consistent with previous studies, which argued that since end-users generally are well conversant with their own business requirements, they are able to perform the analysis better and more accurately resulting in applications that meet their requirements better. The case study investigation, however, found contradictory results on user satisfaction with applications used by other end-users. Whilst end-users in one firm were generally satisfied with the applications they are using, end-users in the other firm had mixed views regarding their satisfaction with the applications used.

The case study provided useful insight in clarifying the issues concerning user satisfaction. It was observed that the end-user developer in one firm found no necessity to consult other users because he could rely on his own experience in the business to analyse the user requirement and develop the applications. As a result the applications that he developed were solely based on his experience of the business and how he wanted the applications to be presented. It was observed that end-users using certain applications such as Customer Inquiry, Personnel and other applications used individually or by few end-users were more satisfied with the application compared to users of Sales, Order Processing and Inventory Control systems. These latter applications tend to be used by larger groups of end-users. For example the Sales application is used by both the Sales and Contract departments, and both Order Processing and Inventory Control systems are used by the Sales, Contract and Production departments. Customer Inquiry is handled by a sales clerk whereas Personnel is maintained by the Administration section.

User satisfaction may be true for applications used individually or in small work-groups, but more studies are needed to examine user satisfaction with respect to applications developed by other end-users but used in larger work-groups or organisation-wide involving different end-users. Insights from the case study investigation in this particular firm found several reasons why other users were not consulted that resulted in less satisfaction with the applications. Firstly, the urgency to automate some of the critical business processes such as Sales, Production and Customer Services. If users were consulted it was thought that a lot of time would be wasted to get users to be involved. The same input could have been obtained through the end-user developer's own personal experience and knowledge of the business activities. Secondly, like other typical small firms, the limited human resources available would make user participation very difficult if not impossible, as users and other employees are fully occupied with their work. The company considered it could not afford to have people away from their jobs even for a short period as the sales or production operation could have been affected.

Thirdly, some of the applications developed were not complete and were being upgraded. These applications consisted of the main modules and basic facilities for users to use and carry on with their business. Since the firm had only one end-user developer, development work had to be prioritised. In order to get as much business processes computerised, only the main databases and modules were developed, leaving other specific applications to be implemented at later stage, depending on the availability of time, resources and urgency of the processes. Under these circumstances the advantage of not getting the other users involved would appear to outweigh the disadvantage of user satisfaction. However, in the long term other users should still be consulted particularly when the time has come to upgrade and enhance the applications.

This experience suggests that, even in a small firm with non-professional developers, the problems of communication with users and achieving a user-oriented design identified in large professionally developed projects can still arise. This is surprising, considering the nature of small firms with fewer employees where people tend to work closer together thereby, in principle, contributing to better communication.

8.2. THE MODIFIED MODEL OF EUC SOPHISTICATION IN SMALL BUSINESS

Whilst the main findings of the survey and case study summarised in the preceding section provide the needed information to understand the sample data, further analysis of the data is required to study the factors contributing to EUC sophistication. Recall that one of the main aims of the research is to study the factors that contribute to EUC sophistication in small business. In addressing this aim, a model of factors affecting EUC sophistication was constructed. Table 8.1 shows the progress of the model development made during this study. It started with the building of the Initial Model previously shown in Figure 3.12 based on issues identified in the literature on IS/IT adoption and EUC studies in both large and small organisations. Thereupon, a survey was conducted to empirically test the Initial Model. This resulted in the Revised Model previously shown in Figure 5.3. The Revised Model was subsequently used as a guideline to support the case study investigation, and evidence from the case study analysis was then used to modify the Revised Model leading to the Modified Model of EUC Sophistication. The Modified Model presented in Figure 8.1 is one of the contributions of this research and will be discussed later in this section.

As presented in Table 8.1 seven factors (including EUC Sophistication and IT Sophistication) were initially identified representing issues studied in the related literature. Based on these factors, 15 variables were identified and their relationships were tested using 28 individual hypotheses grouped into 6 main hypotheses. *EUC Satisfaction* (main hypothesis 6) was the only factor found not to be significant and thus was dropped from the later models. The hypothesis test did not find the significant relationship that relates *EUC Sophistication* to *EUC Satisfaction* (H_{61}).

Table 8.1. Development of the Initial, Revised and Modified models of EUC Sophistication in Small Business

Issues/Factors	**Initial Model** (Figure 3.12) with research variables	**Revised Model** (Figure 5.3)	**Case Study Evidence**	**Modified Model** (Figure 8.1)
Top Management Support	**Hypothesis 1:** Top Management Support of EUC influences the level of EUC sophistication and the presence of EUC in small firms.			
	▪ H_{11}: *CEO Interest* (support) is positively related to *EUC Sophistication.*			
	▪ H_{12}: *CEO Qualification* is positively related to *EUC Sophistication.*			
	▪ H_{13}: The greater the *CEO interest* in EUC, the greater the chance that EUC will be present (*EUC Presence*).	√	√	√
			▪ *Manager Support* influences *EUC Sophistication.*	√
Organisational Characteristics	**Hypothesis 2:** Organisational characteristics determine the levels of EUC sophistication and IT sophistication of the small firms.			
	▪ H_{21}: *Location* affects *EUC Sophistication.*			
	▪ H_{22}: *Location* affects *IT Sophistication.*			
	▪ H_{23}: *Size* of employee is positively related to *EUC Sophistication.*			
	▪ H_{24}: Firms with more employees tend to have higher levels of *IT sophistication.*	√	√	√
	▪ H_{25}: *Sales turnover* is positively related to *EUC Sophistication.*		√	
	▪ H_{26}: Firms with higher *sales turnover* tend to have higher levels of *IT sophistication.*	√	√	√
	▪ H_{27}: *Age of business* is positively related to *EUC Sophistication.*			
	▪ H_{28}: *Age of business* is positively related to *IT Sophistication.*			
			▪ Firm's *profitability* is positively related to *IT Sophistication.*	√
			▪ Strong *EUC Champion* contributes to *EUC Sophistication.*	√
Technology Adoption	**Hypothesis 3:** Technology adoption contributes to the levels of EUC sophistication and IT sophistication of the small firms.			
	▪ H_{31}: The greater the number of *systems* the higher the levels of *EUC sophistication.*	√		
	▪ H_{32}: The greater the number of *systems* the higher the levels of *IT sophistication.*	√	√	√
	▪ H_{33}: The greater the use/range of *technology* the higher the levels of *EUC sophistication.*	√		
	▪ H_{34}: The greater the use/range of *technology* the higher the levels of *IT sophistication.*	√	√	√
	▪ H_{35}: *Application* is positively related to *EUC Sophistication.*			
	▪ H_{36}: The greater the number of *applications* in use the higher the levels of *IT sophistication.*	√	√	√
	▪ H_{37}: *IT Plan* is negatively related to *EUC Sophistication.*			
	▪ H_{38}: The lesser the number of IT products planned to be acquired (*IT Plan*) the higher the levels of *IT sophistication.*	√	√	√

Table 8.1 (continued)

Issues/Factors	**Initial Model** (Figure 3.12) with research variables	**Revised Model** (Figure 5.3)	**Case Study Evidence**	**Modified Model** (Figure 8.1)
Behavior towards EUC	**Hypothesis 4:** Behavior towards EUC influences the level of EUC sophistication, EUC presence and EUC satisfaction in the small firms.			
	▪ H_{41}: *User Attitude* is positively related to *EUC Sophistication.*			
	▪ H_{42}: *User Attitude* is positively related to *EUC Presence.*	√	√	√
	▪ H_{43}: *User Attitude* is positively related to *EUC Satisfaction.*			
	▪ H_{44}: *User Interest* is positively related to *EUC Sophistication.*	√	√	√
	▪ H_{45}: *User Interest* is positively related to *EUC Presence.*			
	▪ H_{46}: *User Interest* is positively related to *EUC Satisfaction.*			
EUC Sophistication and IT Sophistication	**Hypothesis 5**: IT Sophistication is independent of EUC Sophistication and EUC Presence.			
	▪ H_{51}: No relationship exists between *IT Sophistication* and *EUC Sophistication.*	√	√	√
	▪ H_{52}: No relationship exists between *IT Sophistication* and *EUC Presence.*	√	√	√
EUC Satisfaction	**Hypothesis 6**: EUC sophistication is related to EUC satisfaction.			
	▪ H_{61}: *EUC Sophistication* is positively related to *EUC Satisfaction.*			

As discussed in the preceding section, evidence in the case study also found mixed satisfaction among end-users between small groups and larger workgroups. Thus *EUC Satisfaction* was also not included in the Modified Model.

Table 8.1 also shows that a number of variables were excluded in subsequent revisions of the model. In the development of the Revised Model, 4 variables from the Initial Model were deleted since their relationships were not supported by the hypothesis tests. The deleted variables were *CEO Qualification* (H_{12}), firm's *Location* (H_{21} and H_{22}), *Age of Business* (H_{27} and H_{28}) and *EUC Satisfaction* (H_{61}). Altogether 13 individual hypotheses were supported and 15 others were rejected as shown in the 'Revised Model' column of Table 8.1. Results of the hypothesis tests including the supported and rejected hypotheses were discussed in section 5.4.

The remaining variables that formed the Revised Model were then re-tested using evidence from the case study analysis. This time no variables were deleted and only 3 hypotheses were found to be inconsistent with the case study. Two of the hypotheses were dropped because there were no consistent patterns to support their relationships. Both belonged to the technology adoption factor that relates the number of *systems* (H_{31}) and *technology* (H_{33}) to EUC Sophistication. Other evidence was found to support a previously rejected hypothesis, that is *Sales Turnover* is positively related to EUC Sophistication (H_{25}). However, because of the mixed results between the survey and case study analyses, the hypothesis remained out of the model. This is consistent with the concept of triangulation in mixed research strategies as suggested by Cavaye (1996) earlier in Chapter 4.

In Chapter 7 the case study suggested 3 new hypotheses not tested in the previous model. These are *Manager Support* for EUC influences EUC Sophistication, presence of a strong *EUC Champion* contributes to EUC Sophistication, and the firm's *Profitability* affects its IT Sophistication. These new hypotheses together with those earlier confirmed by the study are combined to create the Modified Model of EUC Sophistication in Small Business. This Modified Model is presented in Figure 8.1 below with a discussion of the variables and their relationships that make up the model. Dependent variables that make up the construction of the sophistication indexes will be discussed later.

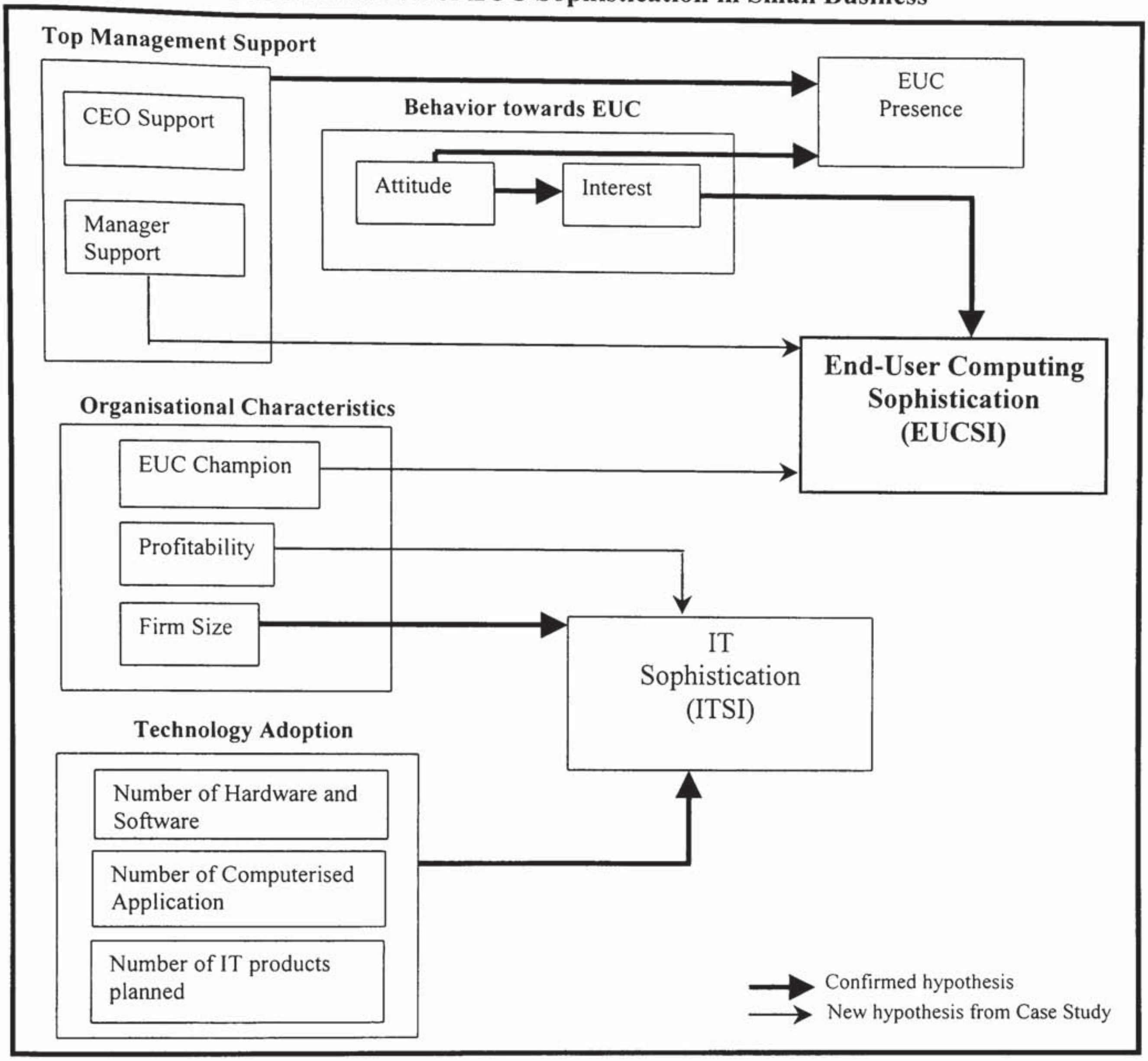
As discussed earlier in this section the case studies have not only confirmed or discredited some of the earlier hypotheses found in the Revised Model but also added new evidence relating to EUC Sophistication in small firms. This is made possible with the better understanding of the EUC phenomenon in its real-life context. The Model in Figure 8.1 below uses thick lines with arrows to signify corroborative evidence confirming earlier hypotheses while thin lines are used to signify new evidence "discovered" in the cross case analysis. Relationships that were initially present in the Revised Model and not shown in the Modified Model of Figure 8.1 were those found to be inconsistent and therefore considered as "threats" to the validity of the Revised Model.

Among the corroborative evidence retained from the earlier model are, *Top Management Support* with EUC Presence, *Behavior towards EUC* with EUC Presence and EUC Sophistication, Organisational Characteristics in the form of the *Size* variable with IT Sophistication, and *Technology Adoption* with IT Sophistication. Only in one instance an earlier hypothesis was not supported and was dropped. This is *Technology Adoption* with EUC Sophistication, where evidence found in the cross-case analysis showed contrasting results between the *number of systems* and *IT products* with the level of EUC Sophistication among the two case firms. Yet in another instance, *Firm Size* that was dropped in the earlier hypothesis because of it not being statistically significant in the hypothesis test was found to have some degree of consistency in the cross-case analysis. However, due to these mixed results the hypothesis that relates *Firm Size* with EUC Sophistication was considered inconclusive and therefore was not included in the Modified Model.

Interestingly two original hypotheses that could not be confirmed in the Revised Model and therefore found to be inconclusive (as represented by the dashed lines in Figure 5.3) are found to demonstrate predictable patterns in the case study. Compelling evidence was found that relates *Top Management Support* with EUC Sophistication, and Organisational Characteristics with EUC Sophistication via the presence of EUC Champions. Apart from the presence of an *EUC Champion*, *Profitability* and *Manager Support* are the other two new variables found to be significant in the study.

Equally interesting is the independence between IT Sophistication and EUC Sophistication claimed in the earlier study and demonstrated by the consistent patterns of evidence in the case studies. This is further substantiated by the rejection of the hypothesis that relates Technology Adoption with EUC Sophistication. This implies that small firms can start on End-User Application Development without substantial investment in IT including acquisition of additional IT products and hiring of IT personnel. What is required is Top Management Support in EUC activities together with a positive attitude for EUC and interests in application development. Whilst a positive attitude towards EUC encourages the presence of EUC, but attitude alone does not demonstrate a direct influence over EUC Sophistication. As suggested by the model, interest in EUC plays a significant role in promoting EUC Sophistication and a positive attitude is required to generate enough interest for this to work. Additionally having an EUC Champion who is influential could further contribute to continued end-user application development within the firm.

Figure 8.1. Modified Model of EUC Sophistication in Small Business



While the Modified Model for EUC Sophistication in Figure 8.1 was adapted to accommodate the evidence from the case study, care has been made to present the evidence consistent to the principles and theory in which the initial model has been based. This is to ensure the results are based on strong theoretical foundation upon which the EUC phenomenon could be better understood and applied and upon which new studies could be based.

8.3. EUC AND IT SOPHISTICATION CONSTRUCTS

Apart from studying the factors affecting EUC sophistication, another aim of the research is to understand the extent small firms are capable of developing their own applications and achieve a higher level of EUC sophistication. This is made possible by constructing two instruments to measure EUC sophistication and IT sophistication. For IT sophistication, an instrument based closely on previous work was created whereas for EUC sophistication, a substantially new approach was necessary as there were no instrument to measure EUC sophistication for small business.

The detailed construction of the EUC Sophistication and IT Sophistication are shown in Figure 8.2 and Figure 8.3, respectively. These represent the expansion of the dependent variables, namely EUC Sophistication and IT Sophistication shown in Figure 8.1 discussed previously in Section 3.5 and summarised in figures 3.10 and 3.11, respectively.

Figure 8.2. EUC Sophistication Index for Small Business

EUC Sophistication Index (EUCSI)

Application Sophistication

- **Sum of Application Weighted Score**

$$\sum_{i=1}^{n} (\text{Weighted score for application i}) * \delta_i$$

for application i in {Word Processing, Order Processing, Accounting/Finance, Customer Services, Spreadsheet, Employee/Personnel, Inventory Control, Telecommunication, Database, Decision Model}
and δ_i is a binary variable {1 if the firm uses application i; 0 otherwise}

End-User Sophistication

- **End-User Typology**
{1, 2 or 3}

Usage Sophistication

- **Number of Users**

Figure 8.3. IT Sophistication Index for Small Business

IT Sophistication Index (ITSI)

- **Software Sophistication Score**

$$\sum_{i=1}^{n} (\text{Weighted score for application i}) * \delta_i$$

for application i in {Spreadsheet, Database, Internet, EDI, DSS, Accounting/Finance, Pricing, Sales, Decision Model, Purchasing, Inventory Control, Fixed Asset, Customer Services, Personnel}
and δ_i is a binary variable {1 if the firm uses application i;
0 otherwise}

The EUC Sophistication Index (EUCSI) shown in Figure 8.2 was adapted from the EUC Sophistication measurement developed by Blili et al. (1996). It was based on three measurement constructs, namely Application Sophistication, End-User Sophistication and Usage Sophistication. As discussed previously in section 3.5, Application Sophistication refers to the complexity of the applications developed by end-users. End-User Sophistication refers to the technical capability of the end-user, and Usage Sophistication is the degree of usage of the application. Using these three constructs a new instrument was developed to formulate the EUCSI as discussed in section 5.2. This instrument was based on the software sophistication construct developed by Kagan et al. (1990) who used the application sophistication ratings of IT professionals from the industry and the academics.

A similar approach was used to measure the IT Sophistication Index (ITSI) shown in Figure 8.3. The one-construct measurement was taken directly from Kagan et al. (1990) where a re-calibrated instrument was developed to re base Kagan's original sophistication construct. The new EUCSI and re-calibrate ITSI instruments have been shown to be reliable and able to predict the IT experts' ratings using combinations of regression analysis, Spearman's Rho Rank Order correlation and Pearson Product Moment correlation as discussed in section 5.2.

The EUCSI instrument shows that all the significant variables are similar to the original Kagan's variables. However, two applications, *pricing* and *fixed assets* that were included in the Kagan's list were not found in the sample survey. These variables were deleted from the regression test, as both applications were not developed by end-users in the sample. Overall the result suggests that there has been little or no change in terms of the applications developed by end-users in small firms in the last decade.

For the re-calibrated ITSI instrument, almost all the IT product variables listed in Figure 8.3 above belonged to the original Kagan's list. Three new variables were included, namely the Internet, EDI and DSS. Interestingly all three products could be considered newer and topical ones. This suggests that their inclusion in the re-calibrated instrument is justified and reflects the evolution of IT in small businesses. Word Processing on the other hand was excluded by the regression test despite being the most popular software used among firms in the sample. This is obvious, as the overwhelming response from the sample for Word Processing has resulted in the variable having little discriminating power compared with the other variables in the study. In this case even if the variable were to be included, it would have made no difference to a firm's level of sophistication in relation to other firms in the sample as other firms will also have the same word processing capability.

8.4. REVIEW AND DISCUSSION OF FACTORS INFLUENCING EUC SOPHISTICATION

The model and sophistication indexes that have been developed were steps taken to address the research aims that relate to the factors affecting EUC sophistication and capability of small firms to achieve higher EUC sophistication level. Specifically, they help to answer the research questions related to the relationship between IT and EUC sophistication and whether end-user development can proceed without increase in IT sophistication. Here the importance of the main factors in the Model such as Management, Organisation, Technology Adoption, and Behavior is discussed and lessons drawn out for the benefits of EUC in small business. These factors along with EUC Sophistication, EUC Presence and IT Sophistication form the structure of the model presented in Figure 8.1.

8.4.1. Management Support

Management refers to the management support of EUC and in small firms this includes the managers and other senior members of the management who have strong influence over the day to day running of the business. Findings from the survey and the case study investigation found that there is a strong interest in EUC among the management in the small firms. These findings also confirmed the original hypothesis that CEO Interest is positively related to EUC presence. That is the more interested the CEO is in EUC the more EUC presence is felt within the firm. The survey result showed that almost half of the end-user developers in the sample came from the middle to top level management. In the case study the main end-user developers were also senior members of the management.

Whilst it is to be expected that the owner or CEO of a small firm is the key person and has the final say in any major decisions involving the business, the case study found that managers tend to assert more influence and have greater responsibilities in the day to day running of the business. This somewhat contradicts earlier suggestion discussed in Chapter 2 that the CEO tend to be autocratic where decisions only come from a single person. Hence a manager in a small firm who has an interest in EUC would have the ability to encourage the presence of EUC and increase the level of EUC sophistication by actually developing his/her own applications or encouraging others, particularly his/her subordinates, to do so. This is shown by a link that relates *Manager Support* with EUC Sophistication as in Figure 8.1. This suggests that in a small firm the need for an application can be quickly and easily satisfied when a manager who has an interest in EUC supports the idea of developing that application. This manager however should be aware of the risks associated with EUC and should be given shared responsibility to manage and control the EUC activities within the firm.

8.4.2. Organisational Characteristics

The only organisational characteristic found in this study to affect the level of EUC sophistication in small business is the presence of an EUC Champion. In the case study investigation the presence of an EUC Champion is clearly seen in both firms. The individuals in these firms are characterised as having a surprising level of skill and knowledge in application development given their non-technical background, having vast experience in the business, and are senior members of the management. Hence the EUC Champion provides a reference point and advice for application development within the firm in addition to his/her more recognised role as the traditional IT Champion. The role of the EUC Champion in this case may be comparable to that of an Information Centre and an IT Department in large firms.

Other organisational characteristics such as firm's size both in terms of the number of employees and sales turnover, age (maturity) of business, and location are not found to be significant in their relationship with EUC sophistication. These organisational characteristics would therefore appear to have no influence over the level of EUC sophistication in a small firm. This is an interesting finding considering previous studies on IT Adoption and IS Success and even EUC studies in medium and large organisations have found significant relationships with these characteristics. The absence of such relationships in this study may suggest fewer constraints on the part of this group of small businesses to embark on EUC. This means that whilst IT Adoption or IS success is dependent upon firm size and the age of businesses, extensive EUC activities can exist in small younger firms with few employees, irrespective whether they are located in the urban or rural areas. Findings with regard to IT Sophistication on the other hand are consistent with previous IT Adoption and IS Success studies. The study found that firm size, both in terms of the number of employees and sales turnover influenced the firm's level of IT sophistication. That is large firms with more employees or higher turnover tend to be more sophisticated in their IT than small firms with less employees and a lower turnover.

8.4.3. Technology Adoption

Technology Adoption was the next factor examined in relation to both EUC Sophistication and IT Sophistication. Technology Adoption is concerned with the number of IT related products used by the small firms. These include the number of systems software (*Systems*), the number of other IT products not within the computer category (*Technology*), the number of computerised business applications (*Application*), and the number of IT products the firms are planning to use (*IT Plan*). As mentioned previously there has been mixed results concerning the influence of Technology Adoption on EUC Sophistication. Based on the survey data both *Systems* and *Technology* were found to be significantly related to EUC Sophistication. However, the case study investigation found that the number of *Systems* and *Technology* products in one firm far exceeded the other. Given that both firms have relatively similar EUC Sophistication indexes the mixed patterns failed to support the survey findings. This therefore suggests that Technology Adoption is independent of EUC Sophistication, which further supports the independence between IT Sophistication and EUC Sophistication. Consistent with these findings, the study also found a strong relationship between Technology Adoption and IT Sophistication. Both the survey and case study found compelling evidence that associates the number of hardware and software (ie. *Systems* and *Technology*), *Application* and *IT Plan* with IT Sophistication. In addition *IT Plan* has also been found to be negatively related to IT Sophistication in both the survey and case study findings. This indicates that the more technology the firms acquired the higher the firms' level of IT Sophistication. For *IT Plan*, as the firms' IT acquisitions are fully met (ie. greater Technology Adoption), there will be less requirements to acquire additional IT products (ie. less *IT Plan*).

8.4.4. Behavioural Factors

Behavioural factors have been a topic of interest in previous EUC studies as well as IT Adoption and IS Success studies. This study confirmed that end-user A*ttitude* and *Interest* are two behavioural factors that are significant in contributing to the firm's EUC presence and level of EUC sophistication. Whilst positive end-user A*ttitude* towards EUC was found to encourage EUC presence in the small firms, A*ttitude* alone is not enough to affect EUC Sophistication. However a positive *Attitude* is required to generate interests among end-users not only to make the presence of EUC felt by actually developing their own applications but also to acquire appropriate EUC skills and knowledge that will eventually affect the level of EUC sophistication. Though no hypothesis was initially defined to study this relationship between A*ttitude* and I*nterest*, the statistical analysis shows a significant relationship exists between these two behavioural factors. This result is also supported by the case study evidence.

All the above factors that formed the model of EUC Sophistication in Small Business could provide useful guidance for small firms in assessing their level of EUC sophistication and the extent they are capable of developing their own applications. Whilst these factors helped addressed the aims of the research, the model along with the whole research process that lead to the development of the model have made several contributions to research and the small business. The following sections discuss these research contributions.

8.5. RESEARCH CONTRIBUTIONS

This study has made a number of contributions to research and the small business. As there have been few studies of EUC in small business compared to large organisations this study has contributed to the knowledge in this area. The following are the contributions made by this study:

8.5.1. Critical Evaluation of the literature

On the basis of extensive search of the literature, whilst there have been numerous studies of IT in small business addressing the issues of IT adoption, IT/IS success and satisfaction, little is known of the EUC phenomenon in small business. In Chapters 2 and 3 it has been established that since small business possess unique characteristics and face different problems from large organisations, they also faced different issues with respect to IT adoption and EUC presence. This study has considerably increased the understanding of the EUC phenomenon by identifying the factors and examining the underlying issues affecting EUC sophistication within small business. A summary of the characteristics of small business and related articles is presented in Table 2.4. Summaries of the factors and issues in the related IT/IS and EUC studies are presented in Tables 2.5, 2.6 and 3.1.

8.5.2. End-User Typology

On the basis of the literature surveyed in this area, this study recognised the need to formulate a new end-user typology in order to study organisations with no formal IS function or Information Centre. The traditional view of "non-programming end-user" and "end-user programmer" is no longer applicable as today's end-users are not always dependent on DP departments and Information Centres. Whilst acknowledging the widely referenced Rockart and Flannery's end-user typology (Rockart and Flannery, 1983), this study has made a contribution by suggesting a simple and pragmatic approach to categorising end-users in small business. A full discussion of this can be found in Dahalin and Golder (1998b) published in an international conference on Small and Medium Enterprises.

8.5.3. Model of EUC Sophistication in Small Business

One of the main contributions of this research is the development of the Model of EUC Sophistication in Small Business. This model allows small firms to understand the factors affecting their capability of developing their own applications, thereby making them self-reliant and independent of external sources. The model describes several main factors influencing EUC sophistication in small firms and addresses the underlying issues that can minimise the risks of EUC. The main factors identified are Management, Organisation, Technology Adoption, Behavioural, IT Sophistication, EUC Presence, and EUC Satisfaction. Some of these factors have been found in previous studies on EUC and other IT adoption studies, and factors such as Management, Organisation, Technology Adoption and Behavioural are particularly relevant in studies concerning technology diffusion. However it is the underlying issues in each of these factors that are of interest and are examined in this study. Understanding these issues will help small firms be better prepared for EUC and increase in their level of EUC and IT sophistication.

The model can also be used as a basis to conduct further studies on EUC or IT sophistication. It can be used as a research framework to replicate this study, or conduct separate studies either using single or mixed research strategies as successfully demonstrated by this research. Any modification or extension to the model as a result of these studies will be considered improvements that could further extend the body of knowledge in this particular area.

As demonstrated by the "action" component of the case study, the model can also be used as a guideline for consultants and the small firms themselves in developing the IS strategies and planning for EUC implementation.

8.5.4. Measurement for EUC Sophistication

Another main contribution closely related to the model is the development of the EUC Sophistication instrument. The instruments used to measure both EUC and IT sophistication can be used to gauge the level of sophistication of the individual firms with respect to their EUC and IT adoption. The sophistication index should give an indication of the firm's level of sophistication in relation to other small firms. Further contribution of the sophistication index, its usefulness and status of development will be discussed later in this chapter.

8.5.5. Independence of EUC and IT Sophistication

Another significant contribution of this research is the surprising independence between EUC Sophistication and IT Sophistication. Initially it was thought that embarking on EUC or the mere presence of EUC in a firm would require certain level of IT sophistication. This was based on prior studies of EUC that often included the presence of a DP or formal IS structure as a prerequisite in their sample in order to study the EUC phenomenon. This study found no significant relationship exists between EUC and IT Sophistication in both the survey and case study results. In addition, there was no evidence to suggest Technology Adoption and EUC Presence affects EUC Sophistication, neither is EUC Satisfaction affected by EUC Sophistication. In the case of Technology Adoption, whilst there is evidence to suggest that Technology Adoption affects EUC Sophistication based on the survey findings, the evidence however is questionable as the findings in the case study investigation found the evidence to be inconclusive. This inconsistency resulted in the original hypothesis being discarded. But Technology Adoption along with Organisational factors has been found to affect IT Sophistication in the small firm both in the survey and the case study findings. What these mean is that small firms can embark on their own application development with minimal investment in IT, even without a formal IT structure. But their level of IT sophistication very much depends on their investment in technology and people resources and of course whether they have the money to invest. Since these are characteristics lacked in many small firms, the independence between EUC and IT sophistication means that small firms could be better off putting more efforts in embarking on EUC than acquiring additional hardware and software and getting the latest technology.

8.5.6. Automated Tool Support

Another contribution of this research is the development of an automated tool support that helps facilitate the IS strategy study, particularly the tedious process of analysing the business areas. Incorporating such tool in the research method would help expedite the research process and the same tool can be used to study IS strategies in other organisations. The tool can also be used by the end-user developer to assist in the IS strategy formulation. It can also be used to support documentation for end-user application development as suggested by Torkzadeh and Doll (1993), and it can also be part of a user-centred tool support as suggested by Lawrence et al. (1995; 1997).

8.6. A CONTRIBUTION TO RESEARCH METHODS IN INFORMATION SYSTEMS

In examining the issues relating to EUC sophistication in small business, contributions have also been made to the research methodologies. The factors and their underlying issues having been initially derived from extensive review of the related literature were then subjected to two rounds of tests involving multiple research strategies. This mixed approach to conducting IS research where EUC like IS itself is multi-faceted has been discussed in Chapter 4. Using combinations of research strategies this way reflects the multi-disciplinary nature of the issue and is justified and should be encouraged for better analysis and reliable results. A research strategy using the survey research followed by case study research is not uncommon in the IS field particularly where the phenomenon investigated is new and the survey findings are inconclusive. Whilst EUC itself has been studied in almost 2 decades applying EUC within small business has been relatively recent. Exploring new phenomenon could lead to an infinite number of variables being studied. With the aid of the Initial Model of EUC Sophistication in Small Business following a critical examination of the related literature, sufficient focus is placed on the research scope to ensure the feasibility of the research study. Furthermore as mentioned earlier findings are subjected to two rigorous tests using two different methods and approaches. Firstly by testing the hypotheses represented in the Initial Model using empirical data from the survey research, and secondly testing the propositions represented in the form of the hypothesized Revised Model using empirical evidence from the case study research. The implication of this is that analysis of the underlying issues are studied from two different perspectives, which can produce either conclusive or diverging results. The important thing is that the findings are much more reliable with the added advantage that they can be better explained. This means that whilst the survey gives breadth the case studies add insight.

The research strategy explained in the research framework follows a strict adherence to standard research methodology for scientific investigation found in research textbooks and IS research journals. The Information Engineering method incorporated in the research framework employs structured techniques for data gathering and identifying business and information strategies. This is to ensure that each step of the research process follows a valid approach using well-proven techniques and methodology. This means that replication of the study can be better achieved and that the small firm will also benefit directly from the study.

It is worth noting that employing a strategic IS approach as part of the action case study method has brought numerous benefits to the research and the firms. In the Information Engineering approach, enterprise data in the form of strategic business and functional area requirements were identified in the process of understanding the firm and its business. Through the series of interviews and observations the enterprise data was synthesised according to several categories to form the research database. This facilitated analysis of the case study research since the database was built based on the Revised Model of EUC Sophistication.

The firms are also able to benefit directly from this study as the approach involved building an information architecture through an Information Strategy Planning study and a Business Area Analysis study. Deliverables from this were of interest to the management because they showed how technology can be used to promote better work processes, increase efficiency and even as a weapon against competition. The process itself invited management to think about the organisation structure, its goals, factors critical for success, critical problem, critical decisions, and their information needs. For the first time an IS Strategy study was conducted for the two case study firms and reports were given in return for their valuable participation. These reports recommend strategies for IS development, IS organisation, and IT supply based on the firms' strategic business requirements. Long-term changes are anticipated that will benefit the firms in terms of increased efficiency and self-reliance on IT appropriate for an action-oriented case study research strategy.

The action-oriented nature of the case study investigation is a useful way of studying IS in the organisations. The implication is that whilst current practices are observable and can be useful for research, the firms participating in the study can also achieve immediate benefits in the form of first-hand contact and advice from the researchers who are knowledgeable in their field. In addition the action case component of the result can be used by the firm as part of its IT adoption strategy. This can be done once investigation is completed and this in itself helps to ensure that the firm will be committed in the investigation and help in its successful completion.

8.7. IMPLICATIONS OF THE RESEARCH

Having reviewed the work in the main body of this thesis the opportunity arises to assess the implications of this work. An evaluation of the EUC Sophistication Index is made, as this is the first attempt a sophistication construct for EUC in small business has been developed. Studying the EUC phenomenon without evaluating its implication on EUC risks would not be complete. Therefore a discussion of the EUC risks is made with emphasis on the small business. In light of the findings from this study implications on recommendations for management and development of EUC in small business will also be assessed.

8.7.1. Sophistication Index

EUC sophistication is measured according to the capability of end-users to develop applications, the degree of usage of the application in the organisation in terms of the number of users, and the complexity of the applications developed. This study has formulated a measurement for EUC sophistication using 3 dimensions of End-User Sophistication, Usage Sophistication, and Application Sophistication. This instrument can be used to measure the extent of a small firm's capability to implement IS by developing their own application. A low sophistication index implies that firm lacks end-user developers with adequate skill, but can produce simple reports and queries with spreadsheet and word processing capabilities, and the applications tend to be used by a small group or on an individual basis. On the other hand, firms with high EUC sophistication index tend to have experienced and skilled end-user developers who tend to develop more complex organisational information systems for use by larger groups of users spanning across departments within the firm. The EUC sophistication measurement can therefore help small firms to assess their own EUC presence and take appropriate actions to improve their capability with respect to application development in particular and IT adoption in general. The usefulness of the sophistication index can be summarised as follows:

- Objective measure for comparison.
  The index and its application variables represent an objective measure where relative comparison can be made to identify a firm's level of sophistication in relation to the others. A small firm could feel more confident of their ability to develop end-user applications as the index represents an objective guide.

- Facilitate assessment of IT adoption and EUC presence.
  Small firms are able to assess their own levels of sophistication in formulating their IT/EUC strategy. The index can be used to show the firms' current position and where appropriate actions can be taken to increase their level of sophistication. This can also be useful for Small Business Advisory and Consultancy services to get quick assessment of the firm's EUC presence and IT adoption.

- EUC application guideline.
  The index and its application variables can be useful for small firms planning to adopt IT or start on EUC. The applications can act as a checklist to guide the firms on the range of applications suitable for their own adoption or development. The degree of sophistication of the individual applications would give the firms a feel of the complexity involved. Though this guideline may come handy, it should not be a substitute for proper IS planning. Recall in Chapter 2 that small business is characterised as having lack of planning. The guideline can become a suitable aid to encourage small firms to plan for their IS.

- Towards a standardised index.
  As there are currently no standardised sophistication indexes, it will be difficult for small firms to assess their current level in relation to the industry. With a standardised index firms could be more sensitive to their IT and EUC needs and this could promote better and healthy competition in terms of IS usage. Working towards a standard index requires replicating the current study in other areas of small business.

- Further research.
  There are potentials for the sophistication index to be used in future research. For example the study of EUC in firms with different levels of sophistication would help to address specific small business problems pertaining to a particular level of sophistication. This could even be extended to a particular sector of the industry. Recall in Chapter 2 that small business makes up over 90% of all businesses and studying specific category of firms would be worthwhile and can still make a significant contribution.

Whilst the IT Sophistication Index has been in existence for almost a decade since Kagan et al. (1990) first developed the Software Sophistication Index construct, this study has made a first attempt to develop a sophistication construct for EUC in small business. Thus, the EUCSI measurement formulated in this study is only in its initial stage. More studies will help improve the index for more confident use by small firms, small business support services, and other researchers.

8.7.2. EUC Risks in Small Business

Studies have suggested that End-User application development in small firms tends to pose more problems and higher risks of failures in all stages of the application development life-cycle compared to large firms and even other small firms with formal IT function and IT expertise. Whilst most studies on EUC have put much emphasis on the importance of such support structure including the establishment of Information Centres, the majority of small businesses are characterised as having lack of formal IT function and IT expertise. However, many previous studies of EUC in small business included only those small firms with an IT department or a formal IT function in their sample. This study on the contrary has made a unique contribution to the specific group of small firms without a formal IT function and an IT professional, which in reality makeup the majority of the small business community. Hence findings of this study are more appropriate and applicable to the wider population of small firms. The scope of research that only included those small firms with no formal IT function and IT expertise has made this possible.

It would be appropriate at this point to reflect on some of the risks posed by EUC in such firms. Earlier in section 3.3.2 of Chapter 3 the risks of EUC have been discussed. Whilst there may be no difference in EUC risks between large and small firms, no studies have yet been done to examine EUC risks within the specificity of small business. Some evidence of EUC risks was observed during the case study investigation. Both organisational and individual risks were identified.

Among the organisational risks associated with EUC identified in the planning stage include lack of formal planning in application development, and lack of strategy for EUC implementation. Though there was evidence of an informal policy on EUC in one of the case firm decision to develop an application is usually short term and depends on the availability of the end-user developer. In the other firm, applications were developed as and when the developer moved to different departments. Individual risks appear to be the lack of planning knowledge and lack of formal management training.

In the analysis stage the organisational risks identified include lack of analysis on user requirements, lack of development methods and techniques, and threats to security and integrity of data. However, there is evidence of proper analysis on acquisition of EUC tools and ensuring compatibility of all hardware and software used. On user requirements, there was evidence suggested earlier in section 8.1 that application development in one of the case study firms was done without consulting other users, which resulted in less user satisfaction with the applications. Lack of formal training in development methodology has also contributed to this as well as the problem of discovering errors too late in the development stage. On individual risks, as well as the lack of formal training by the end-user developer in one of the case study firms, substantial amount of time was spent on performing diagnosis and trial and error during application development. The part-time nature of the work has also made the whole development task more difficult.

A consistent risk found in the design stage is the lack of documentation on the applications developed. A common excuse was the lack of time as the developer has to either catch up with the backlog on his formal work or had to move on to developing other urgent applications. Another organisational risk in the design stage is the development of similar applications used by different departments within the same firm. In the case study an example is the existence of 3 separate stock control applications, two keeping track of the same parts used by the Sales and Production departments, and one for material control application used by the Production department. There was evidence of user tests being done before implementation but that was used more as a platform for user training than for validation and QA procedures. One individual risk identified in the design stage is the frequent changes in the design due to the lack of standard design method. This is exemplified in one of the case firm where the Order Processing system went through three major revisions in 3 years. The third revision was an oversight on the cascading problem in the design of the database due to failure to perform appropriate relational normalisation. This could be seen as an "omission error" suggested by Panko and Sprague (1998) discussed in Chapter 3.

In the implementation stage, the organisational risks identified include, lack of control over security of EUC tools and backup of files. Though these are also risks associated with the general IS issues, they are also EUC risks as it involves operations of EUC applications. One of the case firms relates an incident where its PCs located in one of the department were stolen and because there were no backups, applications used by the department had to be developed from scratch. The situation got even worst when users in another department were affected since their PC was needed to re-develop the stolen application! There was also individual risk in the implementation stage where an application developed by an end-user was not formally recognised but continued to be used by several end-users in the department. Ignoring such talent would not benefit the firm and there could even be potential loss of investment in such "personal" applications when the end-user that develops the applications leaves the organisation.

8.7.3. Implications on Recommendations for the Management and Development of EUC in Small Business

The independence of IT Sophistication with EUC Sophistication found in this study implies that small firms are not constrained by whatever level of IT sophistication they have in order to be able to develop their own applications. This is important for small firms and should be taken into account when formulating their EUC policy in particular and IT policy in general. It helps to rationalise the reason EUC does not require heavy investment nor costly equipment and tools as EUC tools are readily available and are usually bundled together when purchasing a PC. The findings of this study imply that top management intervention is not necessary for an increase in EUC sophistication. However top management support is required to embark on EUC just like seeking permission or consent to implement a new technology into the firm. Once permission is granted the actual EUC implementation and the extent of EUC activities carried out depends on the factors found in this study to be significant to EUC sophistication. These include end-users' interest in EUC re-enforced by their positive attitude towards EUC, support by other managers to ensure continued EUC growth within the firm, and the presence of an EUC champion who has the trust and confidence of the firm on matters regarding IT adoption, IS usage and application development.

From the case study evidence it seems reasonable to suggest that End-User Application Development in the small firms should be properly planned and not left to individual initiative. Top management should be more receptive, instead of putting a lot of constraints on EUC they should allow this trend to pervade the firm. By supporting the idea, EUC should be properly managed just like managing other resources and business areas. In small firms where no IT structure exists, EUC should not be seen simply as an extension of organisational computing as suggested by Raymond (1990a) and demonstrated in the case studies. EUC management should also be an extension of IT management, and EUC policy should also be an extension of IT policy. Likewise, EUC strategy should be part of an IT strategy for the small firm.

In terms of the external environment, agencies supporting small business can also learn from this study to give informed advice on EUC, particularly to those firms about to start on their own in-house development or are actively involved in EUC. Training institutions particularly those supporting entrepreneurial development should also provide different levels of EUC courses to cater for the different levels of end-user sophistication. This could start from the simple word processing and spreadsheet applications to the more advanced development methodology and database design courses. Universities and other academic institutions should also design an appropriate EUC curricular that can be offered to potential non-IT graduates. Courses should include EUC as part of the general IS module, end-user tool support, and development methodology with the aim of producing graduates at the level of end-user sophistication equivalent to the end-user developer. The implication that this has to the small business will be significant as more firms can benefit from EUC and achieve better utilisation of their IT resources.

This study has addressed the factors contributing to End-User Application Development in small business, specifically issues related to EUC Sophistication. Understanding these factors and using them as guidelines will help small firms and other supporting agencies create the right environment for End-User Application Development. However this study should only be considered as a starting point in the study of EUC phenomenon in small business and more studies involving other small firms should also be addressed. In addition, EUC research in small business should also focus on EUC Management, EUC Policy, EUC Strategy, and EUC Risks in relation to EUC Sophistication since existing studies on these have been biased to large organisations with Information Centres and formal IT structures. This seems to be more important now in light of this study which demonstrates and supports the independence of IT Sophistication with EUC Sophistication. The implication is that in the long run there is a danger that not only the firm's IT requirements may not be aligned with it's business missions and goals, but also of the firm's EUC and IT adoption going their separate ways which could be disastrous to the business.

As this study examines issues at the organisational level, it was not a problem that lower end-users were not included. The model produced in this study guides the small business in its EUC strategy formulation. This has been consistently demonstrated in the case study investigation where an IS strategy approach was used to examine evidence at the organisational level, relevant for a study involving organisational adoption. Moreover according to Premkumar and Roberts (1999) studying an innovation adoption at the organisational level should not normally include individual characteristics. This is because organisational adoption examines issues based on consensus from the collective decision perspective rather than from one individual.

8.8. FUTURE WORK

Having appraised the implications of the research and reviewed the research findings and its contributions, other related areas not covered by the research and limitations of the study can now be addressed. These represent potential future work that can be carried out leading from this research and act as a continuous research endeavour in the area of EUC in small business.

In Chapter 1 it was mentioned that the Unit of Analysis in this study is the small firms covering issues at the organisational level. This study has not examined issues at the individual level. However understanding individual characteristics is also important in the study of innovation adoption, as it is the individuals who will eventually use the innovation. Whilst this study has shown evidence that higher level end-users with the capability of developing their own applications comes from the middle management upwards, research should also examine the influence of lower end-users on EUC Sophistication. Individual characteristics such as education and training, EUC skills, business experience, support, responsibility, time constraints, etc. should also be included as they are found to be significant in other EUC studies (Zinatelli et al., 1996; Lawrence et al. 1995).

One of the limitations of this study is the scope of research that only covers small firms in the West Midlands, which traditionally have been a manufacturing stronghold. Despite the type of industry found in the sample survey and case study firms being mainly manufacturing based, the findings are not necessarily only applicable to this sector. Whilst care should be taken when translating the findings to other sectors, the issues and factors identified in this study appear to be universal since they were based on general findings from previous studies. The findings should be relevant to other sectors such as services, construction, and wholesale and retail as they made up 46 percent of the sample. This is also supported by the results presented in Chapter 5 where the findings by industry distribution and cross-tabulation of industry composition did not indicate an excessive manufacturing bias. This is also true in the operationalisation of the sophistication index where manufacturing based products such as CAD/CAM, CIM, MRP, NC machine, etc. were not included in the re-calibrated measurement. The only exception is CAD/CAM being rated fourth among the most popular future IT products planned. However other non-manufacturing firms also use CAD products.

Though it is difficult to assess the consequences of the sample over representing manufacturing industry, similar studies should be carried out in other regions and should also focus on other sectors by replicating this study to help generalise the findings. Likewise, studies should also be extended to other countries with diverse economic and cross-cultural differences.

The units of analysis or the number of case study firms should also be increased to cater for the different combinations of firms with respect to both EUC and IT sophistication. However this can only be achieved at the expense of time and resources at the disposal of both the firms and the researcher(s). In this study both firms have similar level of EUC sophistication and different level of IT sophistication. Future studies should also investigate firms with different levels of EUC sophistication to produce various patterns of evidence and achieve better literal and theoretical replications. In order to ensure shortest possible time to complete the case study investigation there is a need to engage multiple researchers to study these firms simultaneously. Time is critical to ensure the motivation of all involved and delays may affect the momentum of the entire investigation that will lead to failure to complete the case study successfully.

Whilst there is evidence in the survey to suggest that technology adoption in the form of *systems* and *technology* contribute to EUC Sophistication, the same however could not be ascertained in the case study. Whilst the case study evidence would further support the independence of both IT and EUC Sophistication, this contradictory result would only make the finding inconclusive. Hence, further research needs to be done to examine these inconsistencies in order to come to a safer conclusion.

Studies should also be conducted to re-evaluate the sophistication indexes for both EUC and IT within the specificity of small business. Though this study employed the re-calibrated sophistication indexes by re-evaluating existing measurement based on previous studies, independent studies should also be done to compare the finding with this and other previous studies with the aim of developing a standard sophistication index. This could also lead to future studies that can compare sophistication indexes between small and large businesses, particularly with respect to EUC.

Future research should also focus on the study of IT sophistication in small business. Like EUC Sophistication, research on IT Sophistication within the specificity of small business has also been very limited. Since the research focus of the present study has been those factors affecting EUC Sophistication, the presence of the IT Sophistication factor was to test the possible link between the two. Other factors that may affect IT Sophistication were not examined and were assumed to be beyond the scope of the research. Therefore it is essential that studies on the factors affecting IT Sophistication in small business be done and findings from the present study can be used as a starting point for these studies. Again, the multiple research approach adopted by the present study can be replicated to explore and investigate the IT Sophistication construct.

In the case study investigation, efforts were made to develop an automated tool to capture the firms' information strategy and automate the affinity analysis algorithm as part of analysing the business area requirements. Efforts should be made to modify the presentation of this tool particularly the user interface part so that it would have the feel and look of a user-friendly software, easy to use and affordable to small firms. This automated tool would come in handy for future case study investigation, particularly action-oriented cases similar to the present study, and can also be used by consultants or vendors, or even the end-user developers in the small firms themselves. Apart from documenting the firm's information strategy the tool should be able to facilitate the firm's plan for IS including strategy for EUC and IS development. Options should also be made to integrate the tool with other user-centred application development tools, other fourth generation languages and CASE tools.

This thesis has shown that there is a lot to gain from studying EUC in small business. Results from this study can be used by small firms to become self-reliance on IT and not to be too dependent on external sources and IT expertise. Increased sophistication of EUC is possible as EUC is evolved within the firm by addressing the issues and factors found in this study. As more studies are done in this area and with the development of the appropriate tools to support the research process, more contributions can be made to the small business and much of the specificity associated with EUC in the small firms will also be addressed.

The presence of EUC in small business will proliferate as more and more small firms realise the benefits of end-user application development. This research has also shown that almost any small business can embark on EUC and achieve better utilisation of its IT resources, which would in turn contribute to increased efficiency of work processes and productivity. Considering the significance of small business in the economy, if only a small percentage increase was made to the productivity and competitiveness of every small business with EUC, what an immense contribution to the global GNP this would be!

CHAPTER 9. CONCLUSIONS

9.0. INTRODUCTION

This chapter presents the conclusions of this thesis by highlighting the research achievements, research methodology, main contributions and suggesting directions for future research on EUC in small business. The main aims of the research are re-visited and the research questions addressed in the thesis are summarised, together with the hypotheses. The main contributions of the research are summarised, paving the way for future research on EUC in small business.

9.1. RESEARCH QUESTIONS ADDRESSED

In Chapter 1 it was asserted that the idea of conducting this study was to enable small firms to comfortably exploit the potential of EUC. It is appropriate here to re-state the main aims of the research in which this study is based. As stated in Chapter 1, the main aims of the research are:

i. To study the factors that contribute to EUC Sophistication in small business; and

ii. to understand the extent small firms are capable of developing their own applications and achieving a higher level of EUC sophistication.

In Chapter 1, three research questions were formulated to help meet the main aims. To address main aim (*i*) it was necessary to construct a model explaining the factors and their relationships with EUC Sophistication. Main aim (*ii*) was addressed by the following research questions:

1: *To what extent small firms are capable of developing their own applications?*
2: *Are there differences between firms with different levels of IT Sophistication with respect to EUC Sophistication?*

Answers to the two research questions have enabled the third research questions to be addressed, that is:

3: *Is increased IT Sophistication a necessary pre-requisite for the development of EUC?*

The research questions and summary of chapters they addressed are summarised here.

Research Question 1:

To what extent small firms are capable of developing their own applications?

EUC Sophistication is defined as the capability to develop one's own application, the nature and complexity of the application developed, and the degree of the application's usage. The Sophistication indexes (EUCSI & ITSI) were developed to give some indication of this capability. These are achieved through critical review of the literature and the survey research. The case study research provides cross-validation and insights into end-user development. This research question was therefore answered through understanding of the issues on EUC and IT/IS adoption in small business presented in Chapters 2 and 3, and findings from the survey presented in Chapter 5 as well as evidence from the case study presented in Chapters 6 and 7. The research question was addressed by the following summaries of the chapters in this thesis:

Summary of Chapters 2 and 3: Critical examination of literature review.

An extensive review of more than 70 articles encompassing over 20 refereed IS journals examined the issues of EUC in small business, in addition to more than 20 articles on small business characteristics and IT/IS adoption. These articles and their related areas/issues are summarised in tables 2.4 - 2.6 and Table 3.1. Findings from these articles form theoretical conjectures to formulate the factors affecting EUC sophistication in small business. This results in the creation of the Initial Model of EUC Sophistication in Small Business as shown in Figure 3.12.

Summary of Chapter 5: Survey research of IT adoption and EUC presence.

A valid sample of 186 small firms in the West Midlands shows a high level of IT adoption and significant development of EUC among small firms in the region. The findings suggest one in every two firms that adopt IT practised end-user application development. Considering the significant contribution of small business to the economy, issues on small business computing and EUC should be addressed more seriously in light of these findings. Whilst findings from the survey are consistent with previous studies in terms of lack of technical support, IT expertise, and informal

IS function, the significant development of EUC found in the survey represents a step forward to encourage increased in EUC sophistication.

Summary of Chapters 6 and 7: Case Study research of small firms.

The case study research has enabled in-depth investigation into end-user application development of two small firms with moderately high level of EUC sophistication. Hypothesised relationships previously defined can now be examined in their real-life context providing useful insights into the extent of end-user development and the organisation's reaction to the innovation adoption. In addition, the presence of an EUC Champion and strong management support has made EUC sophistication a reality for the two firms. The case study research is discussed in Chapter 6 and analysis of the cross-case results is discussed in Chapter 7. Reports of the case study investigation are presented in appendices 4 and 5.

Research Question 2:

Are there differences between firms with different levels of IT Sophistication with respect to EUC Sophistication?

The issue that firms with certain level of IT sophistication would contribute to low or high EUC sophistication is relevant as more firms will have to decide whether to engage in EUC or encourage further development of EUC. In this study the research question was answered by developing sophistication measurements for IT and EUC. Sections 5.3 and 5.4 of Chapter 5 and sections 8.3 and 8.7.3 of Chapter 8 addressed the independence between the level of IT sophistication and EUC sophistication of small firms. This independence implies that there are no differences between firms with different levels of IT Sophistication with respect to EUC Sophistication.

Summary of sections 5.3, 5.4 (Chapter 5) and 8.3, 8.7.3 (Chapter 8): Development of EUC Sophistication Index and IT Sophistication Index.

The EUC Sophistication Index instrument is used to measure the firm's capability in implementing IS by developing its own applications. The IT Sophistication Index instrument is used to measure the firm's sophistication with IT adoption. Using the sophistication instruments the hypothesis that relates IT sophistication with EUC sophistication found no significant relationship exists with a high degree of independence (R = 0.002 and p value of 0.988). This implies that small firms are not constrained by whatever level of IT sophistication in order to develop their own applications. Operationalisation of the sophistication instruments and results of the hypothesis tests are discussed in the appropriate sections of Chapter 5 and summarised in Chapter 8.

Research Question 3:

Is increased IT Sophistication a necessary pre-requisite for the development of EUC?

Answers to the previous two questions have enabled this research question to be addressed. The extent of the small firms' EUC capability and the independence between IT and EUC sophistication suggest end-user application development can exist in firms with differing levels of IT sophistication. This means increased EUC sophistication is possible by utilising existing IT resources together with the factors found in this study, that is support from top management, presence of an EUC Champion, and positive behavior towards EUC. These factors form the basis of the model of EUC Sophistication summarised in the following section.

9.2. SUMMARY OF THE MODEL OF EUC SOPHISTICATION

Answers to the three Research Questions have enabled the development of the Model of EUC Sophistication in Small Business discussed in Chapter 8. Integral to this model was a set of five main hypotheses that were tested using the survey and case study data as discussed in section 8.2.

Summary of Chapter 8 (section 8.2): Final Model of EUC Sophistication in Small Business.

The final contribution of the study is the Modified Model of EUC Sophistication in Small Business presented and discussed in Chapter 8. The model supports the research aims and addresses all three research questions. It describes the factors found to be significant in contributing to EUC sophistication, the independence between IT sophistication and EUC sophistication, and the possibility of utilising existing IT adoption through increased end-user development.

The model as shown in Figure 8.1 supports the following main research hypotheses:

Hypothesis 1:

- **Top Management Support influences the level of EUC Sophistication and EUC Presence.**

Support for this hypothesis suggests that top management support and management in small firms plays an important role in encouraging EUC. Firms wanting to embark on EUC would need to assess their management commitment before deciding on the innovation. There should be willingness among members of management to be involved in developing applications.

Hypothesis 2:

- **Organisational characteristics determine the level of EUC Sophistication and IT Sophistication.**

Evidence from the case study shows that the presence of an EUC champion in a small firm can contribute to increased level of EUC sophistication. It is therefore important for small firms to recognise and identify an influential person with appropriate skills to champion the course of EUC within the firm.

This study has also found that IT sophistication is dependent on firm's size and profitability. Firms with more employees, higher sales turnover and higher profits tend to achieve higher level of IT sophistication. This is not surprising as increased IT adoption would require more investment on acquisition of hardware and software, and people to use the technology.

Hypothesis 3:

- **Technology adoption contributes to the level of IT Sophistication.**

As expected, firms with high level of IT sophistication would require high investment in the technology. This study shows that this is done through acquiring more systems, greater range of technology, and greater number of applications. A low number of IT products planned is also an indication that high level of IT sophistication has been achieved.

Hypothesis 4:

- **Behavior towards EUC influences the level of EUC Sophistication and EUC Presence.**

Positive attitudes encourage the presence of EUC and increase interest in application development. Positive interest would in turn influence the level of EUC sophistication. Hence positive behavior like Top Management Support influences both EUC sophistication and EUC presence in small firms.

Hypothesis 5:

- **IT Sophistication is independent of EUC Sophistication and EUC Presence.**

As discussed in the preceding section the independence between IT sophistication and EUC sophistication has made "substitution" for increased IT sophistication possible. This means that end-user development is an alternative IT adoption apart from acquisition of hardware and software, third-party development, bureau and outsourcing, customisation and buying off-the-shelf packages. With the exception of EUC the rest of the IT adoption options would require substantial financial implications usually not within the means of small business as defined in this study.

9.3. SUMMARY OF RESEARCH METHODS USED

Development of the final model of Figure 8.1 was made possible through the mixed research methods employed in this study. The following is a summary of the research strategy extracted from Chapter 4:

Summary of Chapter 4: Adopting a mixed research strategy and incorporating an IS strategy approach.

Employing the mixed research strategy has enabled the strength of both the survey and case study research to be appreciated at the same time minimising their weaknesses as discussed in Chapter 4. The research findings discussed in the previous chapter have enabled a fuller and richer understanding of the EUC phenomenon in small business through the mixed strategy. Consistent results have not only contributed to stronger claims of the findings but also able to add insights. The independence between IT sophistication and EUC sophistication addressed by the second question and reflected in the third question is a result of a consistent finding and a quest for in-depth understanding of the relationship. This is made possible through the mixed research strategy.

Incorporating an IS strategy approach as part of the research method helped facilitate the study of IS issues in IS research as experienced in the case study. The Information Engineering method used employed structured techniques for data gathering and identifying business and information requirements. Whilst such a methodology has previously been useful and benefited only the affected firms, it can also be useful and beneficial to IS research as current practices are more assessable to the wider IS research community.

9.4. SUMMARY OF MAIN CONTRIBUTIONS

This study has identified a number of contributions to the understanding of EUC within the context of small business. Some contributions directly answer the research questions posed earlier and able to extend knowledge beyond this study whilst others are useful for conducting future research in this area. Direct contributions include critical review of the literature, the application of the Model of EUC Sophistication, measurement of the sophistication construct, confirmation of the independence between EUC and IT sophistication, and contribution to research methods. Other contributions useful for future research include End-user Typology for small business, and development of an automated tool support. These main contributions have been discussed in Chapter 8 and summarised here as follows:

- Critical Review of Literature.

  As presented in Chapters 2 and 3 and discussed in section 8.5 of Chapter 8, this has contributed to increase in knowledge of EUC in small business. This is particularly useful to pursue further research into EUC in small business.

- End-user Typology.

  As discussed in section 3.1 of Chapter 3 and section 8.5 of Chapter 8, a simple and pragmatic categorisation of end-users in small business was made to reflect the nature of small business characterised by no formal IS function, no IT professional, and no Information Centre.

- Model of EUC Sophistication in Small Business.
  As discussed in section 8.2 of Chapter 8, the model can be used to guide small firms embarking on EUC and to increase their level of EUC sophistication. The model can also be used as a research framework for further EUC investigation in small business. This is to facilitate investigation as used in this research. It can also act as a guideline in formulating the firm's IS/EUC strategy as demonstrated in the case study investigation.

- Measurement for EUC Sophistication Index (EUCSI) for small firms.
  As discussed in sections 5.3 and 5.4 of Chapter 5, and section 8.5 of Chapter 8, this provides the means to assess the firm's level of EUC sophistication and the extent to which a small firm is capable of developing its own applications.

- Independence of EUC and IT Sophistication.
  As discussed in sections 5.3 and 5.4 of Chapter 5, supported by the case study findings discussed in sections 8.2 and 8.5 of Chapter 8, and summarised in section 9.1 of this chapter, the independence between EUC and IT sophistication is important to encourage increased EUC sophistication in small firms. This finding has also addressed the research questions and helped support the aims of the study.

- Contribution to research methods.
  As discussed in Chapter 4 and section 8.6 of Chapter 8, the mixed research strategy used in this study is a good way of studying a multi-faceted subject such as EUC (and IS) where evidence can be examined from different perspectives producing a fuller and richer picture surrounding the subject. Incorporating an IS methodology into the traditional scientific investigation is a contribution in itself, as it facilitates the IS research and is relevant to the IS discipline.

- Automated Tool Support.
  Described in section 6.2 of Chapter 6 and discussed in section 8.5 of Chapter 8, the use of an automated tool support should not only be useful for the formulation of EUC strategy and implementation, but also helps facilitate the research process

itself. This study has demonstrated that such tool can be developed and is useful for these purposes.

9.5. FUTURE RESEARCH DIRECTION ON EUC IN SMALL BUSINESS

Possible future work this study can lead to has been discussed in Chapter 8. These future studies are summarised as follows:

- EUC Sophistication at the individual level;
- EUC strategy, risks, policy and other organisational issues;
- Comparative studies at the regional and sectoral level, and other countries based on economic differentiation;
- Standardisation of the sophistication indexes;
- Automated end-user tool support;

The future direction for research in EUC in small business should examine individual sophistication, both at the individual characteristics level and the individual EUC sophistication level (the independent and dependent factors). There is also a need to look at end-user empowerment and the role of lower level end-users in influencing the presence of EUC and EUC sophistication in small firms. This is particularly relevant in light of the different characteristics possessed by small firms in relation to large firms as discussed in Chapter 2.

At the organisational level, research on EUC in small business should also continue to expand on the work started in this thesis. This should also focus on strategy, risks and policy issues as well as management, behavioural, technology, and intra and extra-organisational issues, some of which have been covered in this study. With such studies the needs of small business would be better understood and the knowledge gained can be used to further encourage small business to embark on EUC.

There is also a need to study EUC in small business across regional and sectoral levels due to the diversity of its operations. This would help generalise findings apart from addressing some of the unique issues that may arise in some regions and sectors of the industry. In addition, similar studies should also be extended across national boundaries and countries in other parts of the world. Such comparative studies could be beneficial as lessons could be learnt in promoting EUC in small business with such diverse economic and cultural background.

Having advanced the general methodology for the construction of sophistication indexes, efforts should be made to standardise them for IT in general and EUC in particular. These indexes can become benchmarks possibly at the regional, sectoral and national levels where firms can assess their own adoption and level of sophistication. Such efforts would also help maintain the relevance of the indexes to reflect the state-of-the-market adoption and usage, and development of EUC applications.

Research direction on EUC in small business should also focus on developing automated tool support not only to ease end-users in developing their applications but also to raise the quality of the designed applications. The tool should incorporate standard development methodology but have the "feel and look" of business tools as oppose to technological tools such as CASE tools used by systems analysts and designers. The whole application development process should be covered from planning to analysis, design, implementation and maintenance, supported by documentation at every stage of the development.

As more studies are carried out to address the issues of IS in general, and EUC in particular within the specificity of small business, better knowledge and understanding of the small firms' IT adoption can be achieved. Whilst recognising the many limitations and risks associated with EUC, through these studies small firms would be in a better position to manage their EUC. They would be able to comfortably embark on their IT adoption with increase in application development, and gain the benefits associated with computerisation. As IS issues unique to the needs of small business are being addressed, the country as a whole would benefit as the majority of businesses and workforce population become more IT literate. This would be a significant step forward for the country's social and economic development and towards the creation of an information-rich society.

GLOSSARY

Ada is a high-level programming language initially used by the US Department of Defense and named after the first programmer Countess Lady Ada Lovelace.

Affinity analysis is a technique used in the *ISP* phase of *Information Engineering* to iteratively cluster objects together based on predefined characteristics.

Application Portfolio is the group of different types of applications identified according to their strategic importance to the firm. The portfolio considered evaluating and prioritising information systems investments in four categories: *Strategic, Operational, Potential* or *Support*.

Application program is a program designed to meet the requirements of a particular individual or organisation, and normally developed specifically for that individual or organisation.

Applications backlog is referred to as the new applications, or amendments to existing applications, that are waiting to be developed or implemented by an organisation's information systems department. In many large organisations, there is an applications backlog several years' long, which prompted many user departments to embark on end-user computing.

Association Matrix is a two-dimensional matrix that record relationships between objects used in *affinity analysis* to cluster closely coupled objects based on their associations with the corresponding objects.

Bus topology is a network topology, in which each computer is connected directly to a main communication line or a *backbone*, called a *bus*. The *bus* can be a twin coaxial cable or thick *Ethernet* 10BaseT or 100BaseT capable of transmitting data at a rate of 10 million or 100 million bits per second, respectively.

Business Area Analysis or *BAA* is a method of analysing the business activities of the enterprise in order to identify requirements for IS. It involves building the enterprise's *data model* and *process model* for each business area identified in the *ISP* phase.

CAD/CAM is the use of the output from a *computer aided design* (*CAD*) process as input to control a *computer assisted manufacturing* (*CAM*) process. This can be an integrated process in which the manufacturing happens automatically. *CAD* is a technique for using the computer for drawing and drafting in architecture, engineering, systems design, and other technical fields. *CAM* is the use of computer to aid in the manufacturing process.

CIM or *Computer-Integrated Manufacturing* is associated with an overall business philosophy aimed at closer integration of the various functions that contribute to the manufacturing process, most of which incorporate the idea of an integrated database of information related to design and manufacturing. This can also includes the administration so that an order or new design need be input only once for use by every business function.

Command Level End-Users are those who are able to write simple queries and can access data on their own. They are able to generate reports on their own and understands the systems elementary functions to specify, access, and manipulate information using report generators and limited set of commands from procedural languages and other fourth-generation languages.

Computer Aided Software Engineering (*CASE*) is a general term for sophisticated computer-based tools that help systems analysts and programmers to design and build application programs. ***I-CASE*** is an integrated ***CASE*** tool that incorporates the formal techniques used in all phases of the Systems Development Life Cycle (SDLC) from the IS planning phase through to the implementation of the IS. This includes the planning, analysis, design, and construction workbenches, and all other system building tools.

Construction involves implementing the designed application and integrating it with the other applications within and outside the business area.

Critical Success Factor or *CSF* is a technique for identifying the information needs of top management. It requires managers and top management to identify those factors that are critical to success in their area of responsibility. These factors in turn suggest important information needs in which potential IS can be developed.

CSMA/CD or ***Carrier Sense Multiple Access with Collision Detection*** is an access control technique of managing data traffic on a *LAN* using the *Ethernet* technology. Whenever a collision is detected, individual computers will wait for a random time interval before retransmission when the network is free.

Data Flow Diagram is a diagramming technique showing the relationships between the data and the processes that manipulate and transform the data within a complete data processing system. The flow of data through the processes is described in a hierarchical way, gradually breaking the processes down to the level of individual programs needed to achieve the system requirements.

Data model is a representation of the data affecting the particular business area operation where the data is of interest to the business area. A *data model* normally consists of diagrams and text describing relevant objects, events and concepts, their main attributes, relationships between them, and a set of rules, constraints and cardinalities that defines how the data can be manipulated. Examples of data models mentioned in this thesis include the *Entity-Relationship Model* and *Data Subject Decomposition Diagram.*

Data Subject is a high-level information requirements of the enterprise and consists of entities that are organised around a particular subject area.

DBMS or Database Management System is a set of interrelated software tools designed to construct and provide access to a database held on a computer system, and to control the privacy, security and integrity of the data.

Decomposition Diagram is a structured model that breaks down the high-level enterprise model into lower levels of details. *Data Subject Decomposition* breaks down a subject area into entities, whereas *Functional Decomposition* breaks down a business function into sub-functions and processes. *Process Decomposition* expands a business process into a set of procedures that can be used to build algorithms and computer programs.

DP programmers is the last and most sophisticated category of end-users. These are the IT professionals who developed sophisticated information systems for the organisation and are well versed in both the traditional third generation languages as well as end-user languages.

DSS or *Decision Support System* is a computer system designed to help people, particularly managers, to make decisions. It will normally provide some means of retrieving and storing the data on which decisions depend, plus various tools that can be used to manipulate the data, in order to model alternatives and explore the consequences of different courses of action.

DTP or *Desktop Publishing* is a class of software that incorporates text and graphics to produce page layouts electronically. Also, the process of using such software for page and graphic design.

EDI or *Electronic Data Interchange*, defined by the International Data Exchange Association, Brussels as the transfer of structured data, by agreed message standards, from computer to computer, by electronic means. The term is also used to mean the exchange of trade transactions electronically between trading partners, example between supplier and customer or distributor.

End-User Computing Support Personnel are those who provide a formal EUC support to the entire organisation. They are normally located in a centralised support structure known as an ***Information Centre***.

End-User Programmers are those who develop their own applications mainly for their own personal use. They are able to use both command and procedural languages to develop the application.

End-User Typology is the classification of end-users according to their capability of using the computers in terms of skills, method of computer use, application focus, education and training and computer support needed. Commonly used classification according to the degree of sophistication include ***Non-Programming End-Users***, ***Command Level End-Users***, ***End-User Programmers***, ***Functional Support Personnel***, ***End-User Computing Support Personnel***, and ***DP Programmers***.

Entities are tangible objects such as customers and products, events such as orders and purchases, and concepts such as credit ratings and sales regions. ***Entities*** are also defined as having certain attributes or properties such as names and addresses, and certain *relationships* with other entities, for example customers place orders, suppliers supply materials, etc.

Entity-Relationship Model is a form of *data model* that describes data in terms of *entities* and the *relationships* between them.

Ethernet is a baseband *LAN* specification developed jointly by Xerox, DEC and Intel to interconnect computer equipment using coaxial cable and transceivers. It can provide 10 or 100 million bits per second (mbps) of capacity for high-speed terminal-to-computer or computer-to-computer file transfer.

Fourth-generation language or *4GL* is an advanced high-level programming language that uses nonprocedural techniques to help end-users specify program requirements.

FTP is an abbreviation for *File Transfer Protocol*, a network protocol for moving files from one host or *server* to another.

Function is a high-level business operation that describes continuous business activities in order to support the objectives and furthering the mission of the enterprise.

Functional Support Personnel are sophisticated programmers who developed applications for other end-users within their particular functional area. They do not consider themselves as IT professionals or DP programmers, rather they are experts in their own business area.

Information Centre (*IC*) is a formal organisation whose main function is to support end-user computing. The support includes not only obtaining the required information for end-users, or helping end-users to obtain these by themselves, but also assisting end-users in using the hardware and software as well as providing education and training in using the computers.

Information Engineering is a structured IS development approach in which the enterprise's information strategy is aligned with the business strategy and these information are kept in a comprehensive knowledge base used to identify, prioritise, design and build the enterprise's information systems. *Information Engineering* consists of four phases, namely *Information System (Strategy) Planning* (*ISP*), *Business Areas Analysis* (*BAA*), *Systems Design* and *Construction*.

Information System (Strategy) Planning (ISP) is the process of planning the organisation's information systems in which the information strategy is defined and documented. It is concerned with top management goals and critical success factors, and how technology can be used to create new opportunities or competitive advantages. The plan requires a high level overview of the enterprise, its functions, data, and information needs. Deliverables of *ISP* include an *IT Supply strategy*, an *IS Organisation strategy*, and an ***IS Strategy***.

IS Organisation strategy proposes a suitable IS organisation that will adequately support the proposed *IS strategy* and *IT supply*.

IS Strategy identifies potential business areas and their underlying applications, their criticality to the business and development priorities. This includes *application portfolios* that best suit the needs of the organisation. One of the key processes involved in *ISP* is the identification and analysis of the enterprise's *Critical Success Factors* (*CSF*).

IT Supply strategy identifies adequate hardware quantities including communication and network infrastructure to support the development and implementation of the proposed systems and applications.

LAN is an acronym for *Local Area Network*, which is an in-house data communications system, usually within a single building, connecting a number of computers together.

Mailmerge is a word processing application that allows the user to send out personalised letters to the names on a mailing list.

MRP or *Manufacturing Resource Planning* is a complex computer-based production planning technique mainly used by manufacturers of complex products, such as engineering companies. Often referred to as *MRP II* to distinguish it from the earlier *Material Requirements Planning*, which is a computer applications where current inventory and production schedules determine the purchase and delivery of raw materials.

NC Machine is an abbreviation for *Numerically Controlled Machine* that uses prerecorded intelligence prepared from numerical data to control a process or machine.

Non-Programming End-Users are those who can only access stored data through software written by others. This is normally done through a limited, menu-driven interface or through a strictly followed set of procedures.

Normalisation is a formal technique used in data analysis, which breaks down complex data structures into simple two-dimensional structures. *Normalisation* is associated with the relational model of database structure.

Operational applications are those where IS/IT is embedded in the core activities of the business such that if the system fails the business has immediate and significant problems - orders or customers are lost, supplies cannot be purchased, etc., leading to real lost of revenue or profitability in the short term.

Outsourcing is the acquiring of services formerly provided by an internal unit from a third-party supplier.

PABX or *Private Automatic Branch eXchange* is a service offered by telephone companies that supports telephone communication within an organisation. It also provides access to the public telephone network.

POS System or Point-of-Sale, a general term for the system of terminals used by sales assistants to capture the details of sales to customers on the spot. Those details are transferred automatically to a computer system elsewhere.

Potential applications are not really systems at all, in that they are areas of R&D that may lead to new systems development. New ideas for systems or new technologies are evaluated to determine what the potential benefits are and whether further developments are worthwhile. Many will prove to be worthless and not feasible but a few may provide the basis for strategic investments.

Process consists of distinct business activities that describe a series of tasks having a beginning and an end.

Process model focuses on describing the activities needed to run the enterprise. A *process model* also consists of diagrams and text describing the steps of processes and procedures that defines the actions to be taken, decisions to be made, and the control mechanism used. *Function/Process Decomposition Diagrams* and *Data Flow Diagrams* are two examples of process models mentioned in this thesis.

Server is a processor that provides a specific service to the network. *Servers* can be classified as: *network servers* that connect nodes and networks of similar or different architectures; *print servers* that provide an interface between one or more printers and one or more nodes on the *LAN*; and *file servers* that provide a central repository of files, programs and data.

Strategic applications are those which enable the organisation to achieve its future objectives and/or gain a competitive advantage. That is either because others do not have such systems or the system is significantly better than those of competitors.

Support applications are those where IS/IT is used to improve the performance of business activities, achieving productivity or efficiency improvements but they are not critical to achieving the current or future business objectives.

Systems Design is the process of translating the user requirements defined in the functional specification into a detailed logical and physical design of an application for a given business area.

10BaseT is a reference to the *Ethernet* standard supplemental definition. The number scheme designates that these networks are baseband networks with transmission rate of 10 Mbits per second. The maximum contiguous cable segment lengths are usually limited to 100 metres because of the signal interference unshielded twisted-pair (UTP) cabling.

WAN or *Wide Area Network* is a telecommunication network that covers a wide geographical area in which computers can communicate remotely.

GLOSSARY OF STATISTICAL TERMS

75th Percentile. The value above which 25 percent of the observed cases fall and below which 75 percent of the observed cases fall.

Bivariate Correlation. The Bivariate Correlations measure how variables or rank orders are related. The correlations procedure computes Pearson's correlation coefficient, Spearman's rho and Kendall's tau-b with their significance levels. Pearson's correlation coefficient is a measure of linear association.

Chi-Square χ^2 test. The most widely used nonparametric test of significance particularly for nominal scale data where significant differences between the observed data category are compared against the expected data category. This goodness-of-fit test compares the observed and expected frequencies in each category to test either that all categories contain the same proportion of values or that each category contains a user-specified proportion of values.

Correlation Coefficient. Identifies both the strength of the relationships between variables by means of the size of the coefficient and the direction of the relationships based on the sign of the coefficient.

Cramer's V. A nonparametric measure of association which is a modification of phi for larger tables and has a range up to 1.0 for tables of any configuration.

Interval scale data. The interval scale has the powers of nominal and ordinal scales in addition to the concept of equality of interval. Example, the distance between 1 and 2 equals the distance been 2 and 3.

Linear Regression. Linear Regression estimates the coefficients of the linear equation, involving one or more independent variables that best predict the value of the dependent variable. For example, you can try to predict a salesperson's total yearly sales (the dependent variable) from independent variables such as age, education, and years of experience.

Nominal scale data. Data values represent categories with no intrinsic order (e.g., job category or company division). Nominal variables can be either string (alphanumeric) or numeric values that represent distinct categories (e.g., 1=Male, 2=Female; 0=Yes, 1=No).

Nonparametric Test. One of the two general classes of significance tests that are used for testing hypotheses with nominal and ordinal scale data. For small sample size the binomial test is used, but for larger sample size the Chi-Square test is most preferred.

Ordinal scale data. Data values represent categories with some intrinsic order (e.g., low, medium, high; strongly agree, agree, disagree, strongly disagree). Ordinal variables can be either string (alphanumeric) or numeric values that represent distinct categories (e.g., 1=low, 2=medium, 3=high).

Parametric Test. One of the two general classes of significance tests that are used for testing hypotheses with interval and ratio scale data. Bivariate correlation, partial and multiple correlations analyses are used for parametric measures of association.

Phi ϕ. A nonparametric measure of association in which a Chi-Square χ^2 based measure is used. Phi ranges from 0 to +1.0 and attempts to correct χ^2 proportionately to N, where N is the total number of observation. Phi is best employed with 2 X 2 tables since its coefficient can exceed +1.0 when applied to larger tables.

Ratio scale data. This scale incorporates all the powers of nominal, ordinal and interval scales plus the concept of absolute zero or origin. The ratio scale represents the actual amounts of a variable. Examples age, weight, height, distance, etc.

Standardised Coefficients. Beta coefficients, sometimes called standardized regression coefficients, are the regression coefficients when all variables are expressed in standardized (z-score) form. Transforming the independent variables to standardized form makes the coefficients more comparable since they are all in the same units of measure.

Stepwise Regression. At each step, the independent variable not in the equation which has the smallest probability of F is entered, if that probability is sufficiently small. Variables already in the regression equation are removed if their probability of F becomes sufficiently large. The method terminates when no more variables are eligible for inclusion or removal.

Unstandardised Beta Coefficients. Regression coefficients used to compute the regression equation. These coefficients represent the predicted values of the independent variables based on their original units of measure.

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APPENDIX 1: THE SURVEY QUESTIONNAIRE

Sample of Cover Letter

December, 1997

Professor Michael Cardwell
Head
Electronic Engineering &
Computer Science
Aston University
Birmingham
B4 7ET

Dear Sir/Madam:

Survey of Information Technology Adoption
And End-User Computing in Small Businesses

At Aston University, we strive to foster close links with local industry as part of our commitment to support the development of businesses in the West Midlands. This survey is part of a research project aimed primarily to assist small firms to make better use of their information technology resources.

The objective of this survey is to obtain information on the level of information technology (IT) use among small businesses in the West Midlands and to explore the presence and potential of end-user application development in those small businesses. Outcomes from this survey would provide better understanding of small firms' use of IT and enable the research team to obtain pertinent information to assist the firms to use IT effectively.

Your firm has been selected for inclusion in this survey as I believe your views will be of significant value to the small business community as well as the academics. I would like to take this opportunity to invite you to spare 10-15 minutes of your valued time to respond to the survey. The enclosed questionnaire has been purposely designed to be short and precise in order to encourage quick and better response. Additionally, whilst participation is voluntary, reminder letters will be made for questionnaires not returned after the suggested dateline.

Finally, the information which you will provide will be kept strictly confidential and no individual firm and person will be named in this study.

The research team is very much looking forward to receiving a favourable response from you. It would help them considerably if you could spare a moment to complete the questionnaire now and return it in the FreePost envelope enclosed. I would like to thank you in advance for your co-operation and help.

Sincerely yours,

PROFESSOR CARDWELL

Sample of Survey Questionnaire

Address Label

ASTON UNIVERSITY

COMPUTER SCIENCE

INFORMATION TECHNOLOGY ADOPTION AND END-USER COMPUTING SURVEY QUESTIONNAIRE

We would be grateful if this questionnaire is completed by the person who is administratively responsible for the company's IT acquisition and/or computerisation. For those companies currently not using IT, we would appreciate if this questionnaire is completed by the CEO, manager, or a staff member who has the most responsibility in the general management of the company.

The purpose of this study is

1. **To identify the level of IT adoption of small businesses in the West Midlands, United Kingdom.**
2. **To explore the presence of End-User Computing in small businesses.**
3. **To assist small firms to make better use of their IT resources.**

If you have any doubts or questions concerning the questionnaire,
Please do not hesitate to contact:

Zulkhairi Dahalin
Researcher
Computer Science & Information Systems
Aston University
Birmingham B4 7ET
Telephone: *0121 359 3611 Ext. 4272*
Fax: *0121 333 6215*
Email: dahalinz@aston.ac.uk

PLEASE RETURN THE COMPLETED QUESTIONNAIRE USING THE FREEPOST ENVELOPE ENCLOSED BY <u>8TH DECEMBER 1997</u>

Part I: General Company Information

1. Company Name and Address (if different from label):______________________
2. Date established:________________
3. Job title of respondent:______________________________
4. CEO's professional or technical qualification/degree:______________________
5. Type of Business:______________________________
6. Industry: (*Please tick one box only*)

☐ Agriculture, Forestry, Fishing	☐ Construction	☐ Financial Intermediation
☐ Mining & Quarrying	☐ Wholesale, Retail & Repairs	☐ Hotels & Restaurants
☐ Manufacturing	☐ Real Estate, Renting & Business activities	☐ Education
☐ Electricity, Gas & Water supply	☐ Transport, Storage & Communication	☐ Health & Social Work
☐ Other Community, Social & Personal Services	☐ Others (Specify):______________	

7. Ownership: (*Please tick one box only*)

☐ Individual ☐ Partnership ☐ Family Business ☐ Private Limited Company ☐ Public Company

☐ Subsidiary of a major, controlling external shareholder ☐ Others (please specify):______________

8. No. of Staff: a) Full-Time:________ b) Part-Time:________ 9. Annual Sales:________

Part II: Use of Information Technology

10. Number of years using IT:________ 11. No. of staff whose main function is to support IT:________
12. a) No. of computers (PCs) used:______ b) Are they networked (Yes/No)?:______ c) No. of users:______
13. Do you use a Minicomputer or a Mainframe? ☐ Yes ☐ No
14. Do you: a) lease or use a computer bureau? ☐ Yes ☐ No

    b) contract out computer processing (outsourcing)? ☐ Yes ☐ No
15. In support of your business activities, please tick your use of one or more of the following:

a) Facsimile (Fax)	☐	f) Modem	☐
b) Mobile Phone	☐	g) Video/Tele Conference	☐
c) Telephone	☐	h) Network Hub, Router, Bridge, Gateway	☐
d) PABX	☐	i) Others:______________________	
e) Personal Organiser	☐		

16. Please tick the appropriate box(es) if you are using or plan to use any of the following:

IT Product	presently using	plan to use	IT Product	presently using	plan to use	IT Product	presently using	plan to use
CAD/CAM	☐	☐	Mail Merge	☐	☐	MRP	☐	☐
Electronic Mail	☐	☐	EDI	☐	☐	Graphics	☐	☐
Internet	☐	☐	Point-of-Sale	☐	☐	Robotics	☐	☐
DSS/EIS	☐	☐	DTP	☐	☐	Expert System	☐	☐
CIM	☐	☐	NC Machine	☐	☐	Word Processor	☐	☐
Spreadsheet	☐	☐	Database	☐	☐			

17. Identify your main business activities by indicating whether they are on 'manual', 'computerised' or using 'other IT products'*. Tick the appropriate box that corresponds to each activity you identified.

**Other IT are technology-driven products not within the computer category (for some examples see question 15)*

Activities	Manual	Computerised	Other IT*	Activities	Manual	Computerised	Other IT*
Accounting/Finance	☐	☐	☐	Invoice/Billing	☐	☐	☐
Contracts	☐	☐	☐	Marketing/Advertising	☐	☐	☐
Credit Control	☐	☐	☐	Material Control	☐	☐	☐
Customer Services	☐	☐	☐	Personnel Management	☐	☐	☐
Distribution/Dealership	☐	☐	☐	Production Operation	☐	☐	☐
Engineering	☐	☐	☐	Project Management	☐	☐	☐
Fixed Asset Management	☐	☐	☐	Purchasing	☐	☐	☐
Forecasting	☐	☐	☐	Sales	☐	☐	☐
Inventory Control	☐	☐	☐	Supplies	☐	☐	☐
____________	☐	☐	☐	____________	☐	☐	☐
____________	☐	☐	☐	____________	☐	☐	☐

If 'other IT' is ticked, please name the product(s):____________________

Part III: End-User Computing

End-User Computing is defined as the capability of managers and staff (ie. non-IT Professionals) to develop their own computer applications for their own use or use by other users.

18. Do you or other staff members use the computer to develop applications? ☐ Yes ☐ No (if 'No' go to Q.21)

19. How satisfied are you with applications developed by users? ☐ ☐ ☐ ☐ ☐

Not Satisfied — Average — Very Satisfied

20. Please indicate the tool(s) used to develop the applications.

Development Tool	Type of Software (eg.lotus,dbase,ms-word,C,etc.)	No. of Users	Developer	Name of Application
Spreadsheet				
Database				
Word Processing				
Programming language				
Others (please specify)				

21. Would you consider it useful for users to develop their own computer-based applications? ☐ Yes ☐ No

Please give your reason(s):____________________

____

____

22. Please describe ONE such application developed by users that would be useful for your business:

____

IMPORTANT NOTE

This questionnaire is the first stage of an on-going research programme aimed to assist small businesses to make the most effective use of their IT resources. The second stage will involve an in-depth case study on a small number of companies to understand the firm's environment and its specific business requirements in order to investigate the presence of End-User Computing.

Outcomes of the case study will help participating firms to plan appropriate information systems strategies in the form of application portfolios, supply of IT, and organisation of their information systems. This will act as framework for the firm's present and future IT adoption.

As this is an academic study, we will guarantee that all information from this study is treated in strict confidence and any reports arising from this study will only be in an anonymous form.

☐ Tick here if you would like to know more about the second stage of the project and how your firm could benefit from the study.

☐ Tick here if you would like to receive a copy of a report from the outcome of this survey as a token of our appreciation for your valued participation.

Other additional comments you may want to write concerning this survey:

THANK YOU FOR YOUR CO-OPERATION

KINDLY RETURN THIS QUESTIONNAIRE USING THE FREEPOST ENVELOPE PROVIDED

APPENDIX 2: PRELIMINARY SURVEY REPORT

Information Technology Adoption and End-User Computing Survey: Preliminary Results

Z. Dahalin and P.A. Golder

Aston University, February 1998

ASTON UNIVERSITY

Introduction

A survey of IT adoption and end-user computing among small businesses located in the West Midlands was undertaken during the months of November and December 1997. The aim was to elicit information on the level of IT use and the extent in which users develop their own applications. Findings indicate that firms participated in the survey are generally IT literate and are moderately sophisticated with respect to IT use. In addition, a significant proportion of users of IT in these firms actually develops computer-based applications for their own use as well as for other users.

This survey is part of a research project, the objective of which is to gain an understanding of the characteristics of small firms in terms of organisational support, technology used, and behavior towards IT. This will help us to see if it is possible to identify and promote successful strategies toward the use of IT and the development of end-user computing.

A preliminary analysis of the survey results is presented; based on a valid response of 186 small firms.

Respondents Profile

Of firms responding 57% were located in the City of Birmingham, 39% in other Birmingham postcode areas and 4% in the wider West Midlands.

Top executives made up the largest group of respondents (77.5%). Other professionals and IT professionals made up the remaining groups with 17.4% and 5.1% respectively. This clearly indicates the findings to represent opinions of end-users of IT mainly occupying the top-level management of the firm. In addition, 77.6% of the responding firms' CEOs have at least a degree or professional qualification. In terms of ownership, private limited companies made up the largest number with 66.7%, followed by family business with 11.8%, partnership with 9.1%, and public companies with 6.5%. Others include not-for-profit organisations (3.2%) and sole proprietorship (1.1%).

In terms of industry composition, the manufacturing sector made up the largest number with 53.8%. This is followed by the construction sector with 12.9%, wholesale, retail and repairs with 9.1%, transport, storage and communication with 4.8%, other community, social and personal services with 4.3%, and financial intermediaries with 2.7%. Real estate, renting and other business activities, hotels and restaurants, and education each contributed 1.6%.

The firms' profiles indicate that the majority are relatively mature business. More than 60% have been in operation for more than 20 years. A closer examination of the data showed that a few of these firms (2.7%) started to use PCs when they were first introduced in the market. About 70% of these firms already existed 15 years ago when end-user computing was first introduced and about 95% of these have already used IT. This indicates that firms in our sample are relatively mature users of IT. Interestingly, 13.2% of the firms have a long history of business having started way back before the turn of this century.

In terms of staff size, slightly more than 70% of the firms employed less than 50 employees reflecting that the majority of the sample came from smaller businesses. Only one-quarter of the sample has no dedicated IT staff and almost 55% employ between 1 and 2 staffs supporting IT. The fact that nearly 75% of the respondents indicated having at least one member of staff whose main function is to support IT is seen to be a positive development for IT adoption within small business. Previous studies have showed small firms experienced limited technical expertise.

Analysis of the IT adoption responses indicates that almost all firms (98%) used at least one PC and about 70% of these computers are networked. Almost all of the responding firms (99.5%) used other IT products such as facsimile, telephones, mobile phones, modems, PABXs, point-of-sales machines, routers, hubs, bridges, and gateways as well as electronic personal organisers in support of their business. The firms in the sample also reported a wide use of different software products, among the most popular being word processors, spreadsheets, databases, mail merge, and the Internet. In addition, more than half of the respondents have indicated their intention to add more software tools with Internet, electronic mail, EDI and CAD/CAM being the four most popular responses.

In terms of business activities, 96.7% of the firms had their accounting and/or financial systems fully or partly computerised. This is followed by a high proportion of firms which had fully or partly computerised their invoice and billing (86.1%), credit control systems (76.8%), sales (66.7%), forecasting (61.3%), purchasing (53.8%), and inventory control (51.6%) systems. Activities that are predominantly manual are personnel management systems (64.4%), project management (59%), marketing/advertising (56.8%), contract (51.7%), and engineering (51.3%).

End-User Computing

The survey has also revealed that substantial progress is being made by small businesses into the area of end-user computing (EUC). This refers to the ability of end-users to develop their own computer-based applications. This phenomenon has been widely accepted in large organisations but little is known of its development in small firms. Previous studies have shown very limited EUC activities have been practised among small firms. This is because of the nature of small business with limited resources and lack of access to technical expertise. Results from this survey indicate however a growing trend towards EUC in small businesses with slightly more than half of the respondents using their computers to develop their own applications.

An analysis of the respondent's choice of software used for development showed that spreadsheets are the most popular tool used with 89.5% response. Within this, Microsoft Excel emerged the number one choice, followed by Lotus, MS-Word, S Calc, Quattro Plus, Microsoft Access, and Microsoft Works. The main applications developed in this category are financial applications such as cost estimates, budgetary controls, and other accounting analyses.

The second most popular development tool is the word processor with 73.7% response. Microsoft Word appears to be the top choice for word processing development followed by Lotus, Microsoft Works, Word Perfect and Word Star. Most of the applications developed using word processing packages are form letters, quotes, and mail-shots.

Next are database packages with 69.5% response. Microsoft Access tops the list of database development tools. Following this are Microsoft Word, Lotus, Microsoft Excel, Microsoft Works, Paradox, dBase, Oracle, Progress, and Informix. The main applications include financial, stock control, service databases, and customer information.

To a lesser extent, programming languages and graphics packages are also used for user development. These include Visual Basic, C++, Internet/Java, Coreldraw, and AutoCAD. Other applications developed by users include forecasting, scheduling, orders, production planning and management, advertising, presentation, Internet, and personnel management.

It is interesting to note that the majority (88.4%) are satisfied with the applications they developed. This supports previous research that suggests users tend to be more satisfied with the applications that they have developed themselves. As few as 1% of the respondents indicated that they are not satisfied with the applications they developed. This is also consistent with the view, that since they generally know their business requirements, users could become good application developers. From the perspective of IT professionals there are reasons to believe that applications developed by users tend to be non-standard, lacking in quality and inefficient. However, because of financial constraints and the lack of professional IT development resources, yet faced with the urgency to automate business processes, many users appear to consider that the advantages associated with computerisation outweigh the risks associated with self-developed applications.

Despite the problems associated with EUC, results from this survey indicate 42.4% of respondents believe it was useful to develop their own applications. Among the reasons given were user's requirements are better met, improvement in efficiency, advantages of a good team spirit, and that applications are nowadays much easier to develop and doing your own development costs less. On the contrary, 57.6% of the respondents rejected the idea that applications developed by users are especially useful. Among the reasons given were that development is too time consuming, development work is difficult to manage, users are not adequately trained in using development tools, users are not employed to develop applications, the applications resulting are non-standardised applications, and self development is too expensive.

Conclusion

Compared with other studies the results of this survey indicate an overall improvement in the level of IT sophistication among small businesses. Whilst other complex applications would require a more formal development methods, certain types of applications particularly the spreadsheet-like and other simple data entry and data retrieval applications appear to be good candidates for end user development. More user-friendly software and good development tools and methodology would obviously enable this trend.

Despite some very encouraging development in the use of IT and end-user computing within small businesses, there is still much need to be done to encourage users to develop their applications. Users need to have knowledge of system design and appropriate development tools in addition to their knowledge of their respective business processes. As today's software becomes more and more user-friendly, users may find developing their own applications a much simpler task and may one day accept this as part of their job responsibility. It is possible that this trend may moderate the effect of the shortage and expense of professional IT as IT professionals will then focus on the more complex and demanding IS development projects involving organisational computing, integration and computer-supported co-operative work.

The Survey

This survey, funded by the Division of Electronic Engineering and Computer Science, Aston University, is part of a PhD research project supported by the University of Northern Malaysia. The survey consists of questionnaires covering aspects of the firm's background, their use of IT, and the respondent's experience in developing applications. The questionnaires were posted to 980 firms located mainly in Birmingham and other West Midlands areas. These firms were randomly selected from a database maintained by the Birmingham Chamber of Commerce and Industry on a commercial basis. A total of 222 firms responded to the survey and 186 questionnaires were found to be valid representing a 23.5% response rate. Posting of the questionnaires, monitoring of returns and data entry was done by the Public Services Management Research Unit, Aston Business School.

APPENDIX 3: SAMPLES OF CASE STUDY QUESTIONNAIRES

EUC Strategy Interview
Company Strategy

Company Name: ______________________________

Address: ______________________________

CEO: ______________________________

Position: ______________________________

Interviewer : *Z. Dahalin* **Date Interviewed:**______________

Description of the Company

1. How did the company first started?

2. What major changes had occurred?

Mission and Goals

1. Your mission as CEO

2. Your goals for each functional area

3. Your main responsibilities

Critical Success Factors

1. What are those things you see as CSFs for your job at this time?

2. In what one or two areas would failure to perform hurt you the most? Where would you hate to see something go wrong?

3. If you were isolated from the business for 2 weeks, with no communication at all, what would you most want to know about the business?

Problem Analysis

Criticality Rating:
5 = Critical to operation of business
4 = Critical to undisrupted operation of business
3 = Required to support business
2 = Required to support business, but to a lesser degree
1 = Desirable, ie good to have

1. What are some of the problems you have had in meeting these goals? (refer to goals)

2. What has prevented you solving them?

3. What is needed to solve them?

Information Needs

1. What is the most useful information you received? (ensure best aspect of current systems retained)

2. What information would you most like to receive?

Decision Making

1. What kinds of decisions are you expected to make?

2. What computer aids might help in your decision making?

Future

1. What major changes are expected in your business in the next year? (Future Plans)

2. Next 3 to 5 years?

3. What do you expect, and what would you like, to result from this study?

Other Matters

1. What do you think of computers?

2. Any additional views or comments?

EUC Strategy Interview
Business Function

Company Name: ______________________________

Address: ______________________________

Interviewee(s): ______________________________

Position(s) : ______________________________

Interviewer : *Z. Dahalin* **Date Interviewed:** ______________

Organisation Unit : ______________________ **Chart:** ☐

Business Function : ______________________

Description of Business Function

1. What are your responsibilities?

2. What are the main business activities?

Goals

1. What are the basic goals of your area?

Organisational Sub-units

1. Basic description of sub-units (in terms of responsibilities and goals)

Critical Success Factors

1. What are those things you see as CSFs for your job at this time?

2. In what one or two areas would failure to perform hurt you the most? Where would you hate to see something go wrong?

3. If you were isolated from the business for 2 weeks, with no communication at all, what would you most want to know about the business?

Problem Analysis

Criticality Rating:
5 = Critical to operation of business
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1 = Desirable, ie good to have

1. What are some of the problems you have had in meeting these goals? (refer to goals)

2. What has prevented you solving them?

3. What is needed to solve them?

Information Needs

1. What is the most useful information you received? (ensure best aspect of current systems retained)

2. What information would you most like to receive?

3. How would you rate your current information support with respect to:
   Scale used: Timeliness - {Fast, Moderate, Slow}(F,M,S)
   Accuracy - {Accurate, Not Accurate}(A,NA)
   Adequacy - {Adequate, Not Adequate}(A, NA)
   Cost - {Cheap, Not Cheap}(C, NC)
   Consistency - {Consistent, Not Consistent}(C,NC)
   Ease of use - {Clear, Not Clear}(C,NC)

Types of Information					
Timeliness					
Accuracy					
Adequacy					
Cost					
Consistency					
Ease of use or clarity					

Decision Making

1. What kinds of decisions are you expected to make?

2. What computer aids might help in your decision making?

Future

1. What major changes are expected in your area in the next year?

2. Next 3 to 5 years?

3. What do you expect, and what would you like, to result from this study?

Other Matters

1. Any additional views or comments?

EUC Strategy Interview
EUC Sophistication

Company Name: ______________________________

Address: ______________________________

End-User: ____________________ **Position:** ____________

Organisation Unit: ____________________

Interviewer : *Z. Dahalin* **Date/Time Interviewed:**_________

End-User Profile

1. Age Group: [<=20;21-30;31-40;41-50;51-60;>60]
2. Job Experience
3. IT Experience (previous and current employment)
4. IT Training (past and future) - Type, duration, benefits (reasons)
5. IT tools familiar with (past and future)
6. Application development experience
7. Description of development method
8. Tools used for development
9. Rockart and Flannery Classification [non-prog; command-level; EU prog; functional support]
10. Behaviour towards IT (Attitude: Do IT creates more unemployment)
11. Behaviour towards EUD (Attitude: Do you think it's a good idea for users to develop their own application? Why or why not?)
12. Has dealing with IT or EUD ever affect you? (Anxiety: job performance, pressure, relationship with colleagues, superior, subordinate)
13. Awareness (refer to 2,3,4 above)
14. End-user development guided by (autonomous, technical person, other user, external)

End-user Tasks (Usage)

1. Application:

____________________[many times a day; few times a day; few times a week; few times a mth, once a mth, < once]
duration of use:[whole day; whole morning or afternoon; 1-2hrs a day; 0.5-1hr a day; <0.5hr a day]

______________________________[many times a day; few times a day; few times a week; few times a mth, once a mth, < once]
duration of use:[whole day; whole morning or afternoon; 1-2hrs a day; 0.5-1hr a day; <0.5hr a day]

______________________________[many times a day; few times a day; few times a week; few times a mth, once a mth, < once]
duration of use:[whole day; whole morning or afternoon; 1-2hrs a day; 0.5-1hr a day; <0.5hr a day]

______________________________[many times a day; few times a day; few times a week; few times a mth, once a mth, < once]
duration of use:[whole day; whole morning or afternoon; 1-2hrs a day; 0.5-1hr a day; <0.5hr a day]

______________________________[many times a day; few times a day; few times a week; few times a mth, once a mth, < once]
duration of use:[whole day; whole morning or afternoon; 1-2hrs a day; 0.5-1hr a day; <0.5hr a day]

2. Percentage of time spent on IT versus business activities

Application Sophistication

1. Type of application (percent of reporting, inquiry, analysis, data entry)

2. Mode of operation: printed reports

   Dumb terminals

   PC standalone

   PC Networked

3. Development tool(s) (3GL, 4GL)
4. Origin of application [yourself; yourself+user; yourself+IT specialist;other user]

End-User Tools

1. Advantage of tools used
2. Complexity (ease of use)
3. Compatibility of tools
4. Trialibility (used first before purchase/accessible by others to play with)
5. Observability of tool

- Visibility (end-users know such tool exists)
- Result demonstrability (others aware of tool's capability)

6. Image (is the tool used because of it's popularity?)

7. Voluntariness (is the tool used by force?)

EUC Strategy Interview

IT Inventory

Company Name: ______________________________

1. Hardware

Location	Hardware (network?)	Type (eg 486DX,Epson)	No. of Units	Status (ok,repair)	Usage (used,not used)	Reason	If PC	
							RAM	HDD

2. Configuration Diagram (Topology)

3. Software

Software (package/application)	Usage Status	Operating Environment	Department/ Location

4. Applications Configuration

5. Size Investment (% of IT investment)

6. Number of End-Users and Typology (Non-Prog; command-level; EU prog; functional support)

7. Support

- Access to IS/IC services
- Access to outside consultants or vendors
- Access to informal network
- Documentation and manuals
- Backup and recovery procedure

APPENDIX 4: INFORMATION TECHNOLOGY RESEARCH REPORT FOR BRITANNIA HEAT TRANSFER LIMITED

CHAPTER 1. INTRODUCTION

1.1 Background. *A need for an Information Systems Strategy.*

Organisations, whether large or small, should have the capability to process their own data and use information effectively to be able to compete and become successful. This is especially true in today's fast changing environment, which would require equally fast access to information to cope with the rapid change. Information is used on a daily basis to perform such functions as planning, control, organising and decision-making. Thus, information is a critical resource for an organisation like Britannia Heat Transfer Limited. Any means to assist the company to process and manage information whether mechanical or otherwise should be sought.

During the 1980s, a lot has been said regarding the need for organisations to adopt a strategic approach to manage investment in information systems and technology. In fact, in the late 80s and early 90s, organisations begun to pay more attention on information systems strategy - an organisation's plan to acquire appropriate IT infrastructure such as the supply of suitable hardware, software and telecommunication facilities for the utilisation of applications required by the business with adequate support structure. There were 2 main reasons for this approach.

Firstly, as most organisations were facing one of the worse recessions in the 1980s, majority of their investment has failed to obtain expected returns. This has made the organisations reluctant to spent on IT as they may not achieve the return on their IT investment as expected. Secondly, on the other hand, the use of information systems (IS) by several innovative firms proved that they can achieve competitive advantage. This shows that the use of IS has strategic benefits for these firms. In both of these, IS has become a critical business issue, that is to ensure it is used fully to achieve maximum benefits.

Without the necessary strategy for IS investment several problems may arise, which include:

- Lost of business opportunities, where the business fail to compete because of the use of IS by other organisations. The investment on systems and technology fail to support the business objectives and may become a constraint for further development of the business;
- Lack of integration between systems and data management could result in duplication of efforts, lack of data integrity, inaccurate information, obsolete information, and inadequate information to manage the business;
- IS priorities not based on business requirement, which could result in under-utilisation of resources, and planning for projects that are constantly changing. This will affect business performance, increased in cost, low quality products, and decrease in IS productivity;
- Inconsistent IT strategy, incompatible solutions and lots of money will be wasted in efforts to correct the situation; and
- Lack of understanding and directions between users of IS and top management, as well as those responsible for IS development. This may result in conflicts, inappropriate solutions, and misuse of resources.

The above problems may arise as a result of failure by organisations to plan for their IS in a strategic manner. That is adopting an IS planning approach based on the organisation's business requirement and making IS strategy as part of the organisation's business planning process.

Realising the importance of an IS strategy for the company, the top management of Britannia has agreed that an IT research on IS strategy be conducted and the result of the study is documented in this report. The research is part of a case study investigation to explain a specific IS issue namely the End-User Computing phenomenon within the context of small business. A separate analysis will be done to examine End-User Computing sophistication and an attempt will be made to formulate a viable strategy for End-User Computing within the specificity of small business. With an IS strategy in place, implementing an End-User Computing strategy will benefit many small firms, including Britannia, which are currently adopting IT but lacked the technical expertise to develop their own application.

1.2 Objective of the Study

This study aims to formulate an IS strategy for Britannia by developing a high-level overview model of the enterprise's information requirements. This overview model is an initial attempt to create an *information architecture* for Britannia and this can only be made possible by taking into consideration the company's mission, business goals and objectives, business functions, human resource requirements, current investment, and current and future IT resources.

1.3 Target of Study

The main target of this study is to support the business objectives of the management of Britannia. The study begun by analysing the corporate mission and Britannia's future direction by adopting a top-down approach in Britannia's organisation structure. From here strategic goals of the organisation will be identified together with determining those key areas where things must go right for the business, better known as critical success factors. Next, a top overview of the organisation, functional requirements, data and information needs of key personnel will be identified to ensure that the IS strategy is aligned to the company's business needs. In this context, the management of Britannia through the outcome of this study would be able to identify information that are required to support their objectives, functions and critical success factors in a more effective way. Targets of this study include:

- A suite of application portfolio and potential end-user development
- Formation of a corporate database
- Technical environment including hardware, software and networking
- Organisation of information system

1.4 Deliverables

Among the deliverables of this study are as follows:

- This report
- Statements of Britannia's information requirement
- Strategies for the adoption of IT that could potentially increase business performance and enhance Britannia's services
- Realistic planning to achieve the above targets

1.5 Methodology

The methodology used in this study is based on a structured development approach known as *Information Engineering*. As described by James Martin, Information Engineering is a systems development methodology that applies structured techniques to the enterprise (firm) as a whole or to certain major segment of the enterprise. Information Engineering progresses in a top-down manner through four basic levels, namely: (1) *Information Strategy Planning* as applied to the enterprise as a whole or to a subset of it in which an information architecture is built based on a high level function models and data models; (2) *Business Area Analysis* in which the enterprise's data models and process models are built for each business area identified in (1); (3) *Systems Design* that establishes a detailed logical and physical design of an application for a given business area; and (4) *Construction* in which the designed application is implemented and integrated with the other applications within and outside the business area. For the purpose of this study however, the first two levels namely Information Strategy Planning and Business Area Analysis have been applied and together formed the major tasks performed by the researcher for the purpose of modelling the strategic information for Britannia Heat Transfer Limited as an enterprise. The first two stages were deemed to be adequate and appropriate to meet the objectives of this study as both stages are capable of representing and delivering a high-level information requirements of the enterprise.

The study took off when the CEO, who is also the owner of Britannia Heat Transfer Limited agreed that the study be undertaken. The first task is to gain as much information about the company through the company's reports, brochures and access to its internet WebPages. Next, key personnel were identified representing major departments within the company. Information on each department's business functions, goals, critical success factors, problems and information needs were recorded and documented. On the basis of these information, first-cut enterprise conceptual models were developed. The models were high-level overview models and concerned with formalising Britannia's goals, critical success factors and business functions. The models were described using the information engineering tools such as hierarchy of goals and functional decomposition.

Data and fact-findings were done through several phases of semi-structured interviews, first with the key personnel responsible for each department and then the main user who is also responsible for IT. Among the key personnel interviewed was the Executive Director of Sales and Marketing, Manager of Contracts Department, Manager of Quality Assurance, and the General Manager of Development (Elfin) who is responsible for R&D and IT as well as acting as the Production Manager for the purpose of this study. A final interview was also done with the Chief Executive Officer on the company's mission and general direction as well as to trash out any outstanding issues raised during the interviews with the key personnel. A total of eight interviews were held in a time-span of approximately 2 months each lasted between two to four hours.

Extracting the required information from the interviews in addition to the company's reports, forms and other documentation formed the first-cut conceptual model. The model was decomposed into two major models representing data and activity. The activity model was initiated by extracting the high-level functions from the conceptual model and further decomposed into a series of low-level functions. The result of the activity model is displayed using the function decomposition diagram.

Identification of subject areas acted as the starting point for developing the data model. Subject areas were identified by looking at the data requirements to perform those high-level functions defined in the conceptual model. In addition, subject areas can also be extracted by analysing the critical success factors. These subject areas are then decomposed into a series of entity types. Once the required entity types were identified, relationships between entities and their respective cardinalities can be defined. These can then be mapped to form an entity-relationship model (also known as ER Model). The ER Model can be used to represent the detailed information requirement of Britannia.

The next step in the study was to produce recommended business areas that identified the required applications. This was done through two processes. The first process was to create an association matrix mapping entity types and functions according to their usage. Those entity types used by each function were checked. The output was the function-entity matrix. The second process was to perform an affinity analysis - an analysis based on entity clustering algorithm using the function-entity matrix as input. The algorithm proceeded by clustering those entities utilising the same functions to form an application group (business area) based on their affinity.

CHAPTER 2. ORGANISATIONAL ENVIRONMENT

2.1 Company's Profile

Britannia Heat Transfer Limited (Britannia) was established in 1989 as a manufacturing company for the heat transfer industry. The company is located in a sub-urban area of Birmingham within the Coleshill Industrial Estate 45 km from the city. Its primary business is in the design, manufacture, and supply of a wide range of heat transfer products and associated components and materials that include heat exchangers, coolers, condensers and tubes. The demands for Britannia's products and services come from diverse customer bases which include the utilities, petro-chemical, marine and other industrial firms both within the UK and overseas.

Britannia employed 45 full-time staff, 20 in the site office and the remaining 25 in the shop floor within the same location. As part of its expansionary plan to increase productivity and to improve the quality of its products, the company is recruiting more people with the right skills and experience in order to move forward into the next millennium. The company has an annual sales turnover of approximately £4 million with sales mostly in the domestic market. With well proven, high quality products, the company aimed to increase its export internationally and forming strategic alliances with companies abroad in order to be more competitive. Britannia hoped to increase its sales to £6 million forecasted for 1998 with profits (before tax) of well above the £½ million registered in 1997. Britannia is optimistic of achieving a steady growth rate of 30% per annum. This is made possible through its plans for expansion both within the management structure and its physical infrastructure, which includes its range of products and services, manufacturing facilities, technological innovation, and layout. Britannia is also planning to diversify its business to span across hi-tech markets and other non-traditional industries such as the rail industry, aerospace, and nuclear.

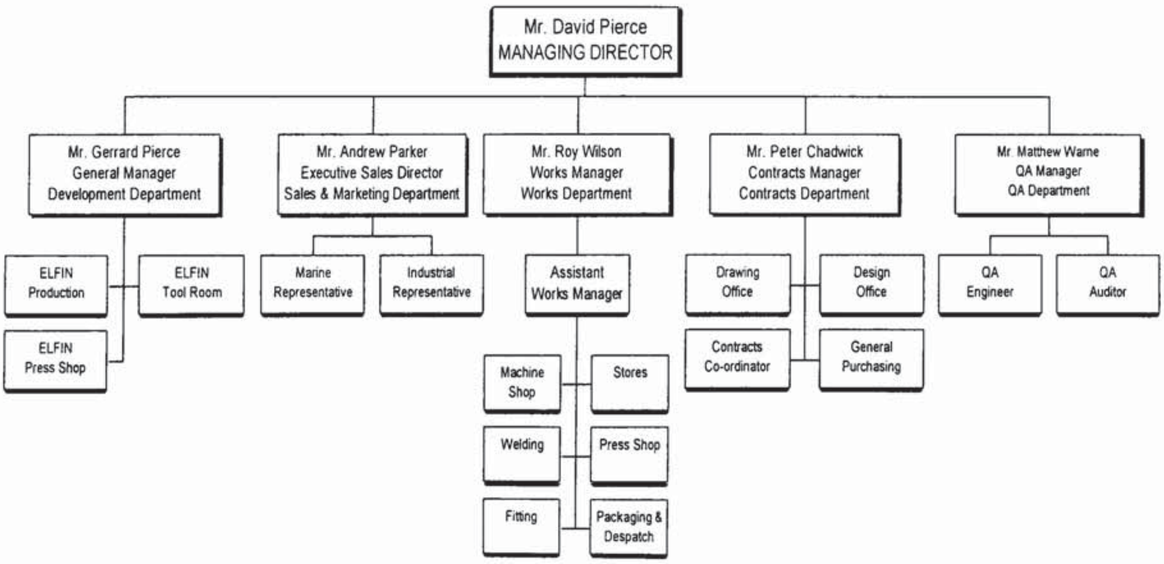
Britannia has a wide range of facilities to support its present and future customers. These include facilities to design and manufacture heat exchangers, repairs and re-manufacture heat exchangers, tube manipulation, CNC drilling and turning, NC machining, CAD/CAM, boring, milling, welding, cutting, pressing, and finning. The major products manufactured through these facilities include Shell and Tube units, Air Coolers, U-Tube bundles and coils, and a variety of heat exchanger tubes. Underneath each major product are a variety of products, components and materials such as generators, transformers, condensers, alternators, circulators, pumps, tube plate facades, tube plugs, heating and condensing elements, etc.

2.2 Organisation Structure

According to Britannia's organisation chart up until the month of June 1998, Britannia is lead by a managing director who is also the owner of the company. He was responsible for setting up the company eleven years ago and he has been developing the company ever since, both in terms of products and its people, to what it is today. Having 20 years of experience in the heat transfer industry, he is very optimistic of the company's future and believed that Britannia will one day become the world's leading company in the heat transfer industry.

There are 5 departments supporting the managing director each headed by senior and experienced managers. These departments are the Development Department, the Sales and Marketing Department, the Works Department, the Contracts Department and the Quality Assurance Department. There is also an Accounts and Administration section handled by a part-time accountant responsible to the managing director. Figure 1 below is the company's organisation chart with the rest of the operating units shown.

Figure 1. Britannia Heat Transfer Limited



2.3 Functional Areas of Departments

The **Development Department** is the R&D arm of Britannia. It is strategically positioned within the company to continuously develop new products and enhance the quality of existing products in line with the company's desire to maintain high quality products and to be innovative. The department has a team of development staff headed by a General Manager, who is a senior member of the management team to materialise new ideas and innovation. The resultant products have been proved to be successful in the past with emergence of the patented Elfin group of products in the market. The department is also committed in the company's desire to modernise its business through the adoption of information technology and acquiring the latest, state-of-the-art CNC machining in order to become a specialist hi-tech manufacturer. The 3 units supporting the Development Department are the Elfin Production, the Tool Room, and the Press Shop.

The **Sales and Marketing Department** is responsible for the general sales of Britannia's products and services. It is managed by an Executive Sales Director who has years of experience in heat transfer particularly in the marine industry. Apart from generating sales leads and overlooking the overall sales activities of the company, the Sales Director is also involved in trade missions and advertisement to promote the company's products at home and abroad. The department is supported by 3 units, namely the Marine, Industrial and Sales Agents. Britannia has a long tradition in the marine industry and the Marine unit is dedicated to support and sustain its specialisation in this industry. The Industrial unit caters mainly for the domestic market whilst Sales Agents are autonomous agents located in various parts of the world. The department is also emphasising sales over the rail and power generation industries in line with the company's overall strategy to diversify into other market areas.

The heart of Britannia's manufacturing activities is the **Works Department**. The shop floor houses the physical work areas where personnel and machines processed materials according to specified job schedules. The Works Manager oversees the general management of the shop floor, planning the job schedule and allocating personnel and machine resources. He is assisted by an Assistant Works Manager and supported by foremen and shop floor personnel. The department has 5 units each performing production activities at a certain stage of the manufacturing process. The units are the Machine Shop, Welding, Stores, Fitting, and Packaging and Despatch. Each unit is supervised by a foreman to ensure the smooth running of the daily production operation.

The **Contracts Department** can be viewed as an intermediary between the Sales and the Works departments, both involving pre and post-production activities. The department is also responsible for providing technical support for pre and post-sales activities and because of this there are times when certain sales are handled directly by this department. Headed by a diligent and well-experienced Contracts Manager, the department is supported by staff in 4 units. These are the Design Office, the Drawing Office, the Contracts Co-ordinator and General Purchasing. Apart from the typical contract works, the department also handles the purchasing of materials for specific jobs and arranged for transportation for delivery of finished products and/or components to the customers.

Another important department within Britannia is the **Quality Assurance** (QA) Department. The department is headed by the QA Manager and supported by a QA Inspector and QA Auditors. The department ensures that job specification of a certain job-in-progress as well as the finished product follow the company's own standards and comply with the industry standards as specified in the ISO 9001 documents. This is in line with the company's desire to maintain high quality standards for its products and in the process increasing product acceptance at the same time minimising or eliminating rejects and non-conformers altogether. Frequent inspections and tests are done on materials and finished products.

CHAPTER 3. BUSINESS ENVIRONMENT

3.1 Britannia's Strategic Plan

Part of the effort to acquire an IS strategy is to examine the company's strategic business plan. The *information engineering methodology* calls for the alignment of IS strategy with the company's business strategy so that any IS implementation will support the business in terms of its mission, goals and business functions. Hence Britannia's strategic plan is a prerequisite for its IS strategy formulation, and the success of the research study depends on whether such a plan exists. In the absence of a documented plan as in the case of Britannia, an alternative is to seek senior and top management's view of the current state of the business as well as their opinions regarding the future direction of the business. This is done by conducting semi-structured interviews to identify the company's mission, business functions, organisational units and their functional areas, strategic goals and objectives, and critical success factors and problems. The following sections describe Britannia's business strategy based on interviews with top and senior management of the company.

3.1.1 Mission Statement

Though no formal mission statement has been identified, Britannia's mission could be described based on the perspective of the top management. Thus, an appropriate mission statement for Britannia is:

We are committed in our people and we strive for product excellence to be the number one in our area and to be recognised internationally

3.1.2 Strategic Goals

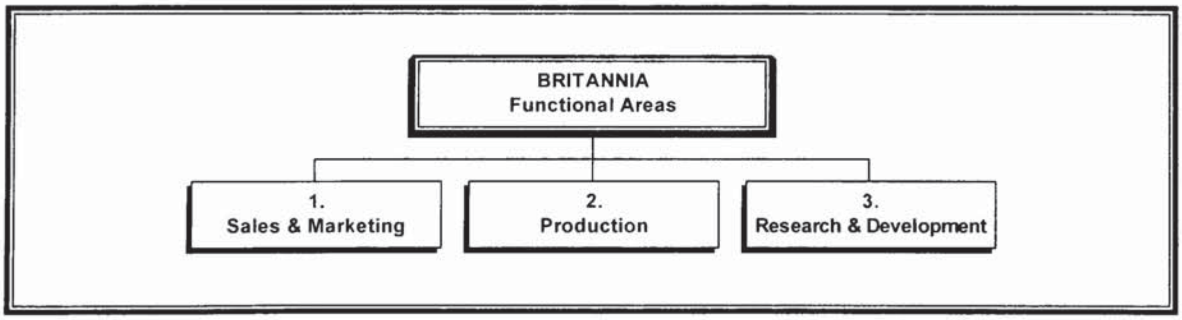
To support the above mission, a number of strategic goals have been identified.

- Diversify into hi-tech markets while sustaining the traditional marine business
- Introduce modern, state-of-the-art technology company-wide
- Increase production capability
- Improve product quality through better skills and machinery
- Enhance research and development by investing £150,000 a year on R&D
- Become an Original Equipment Manufacturer for world-wide distribution
- Sell products internationally at very competitive prices
- Increase sales turnover by £2 million a year
- Maintain growth rate at 30% per annum

3.2 Business Functions

Britannia's business can be broadly categorised into 3 functions. These are the Sales and Marketing Function, the Production Function, and the Research and Development Function. Figure 2 below depicts the three high-level functions of the company.

Figure 2. Britannia's Business Functions



The above figure also known as *Functional Decomposition Diagram* is used to sub-divide or decomposes each of the main function into several sub-functions. Each sub-function can further be decomposed into sufficient levels of detail to determine distinct business processes and activities. However, for the purpose of obtaining a high-level overview of the enterprise, decomposition will stop at the sub-function level or when the lowest-level function is reached.

A summary and breakdown of each of the main business function are described below using the sub-function decomposition diagram.

Figure 3. The Sales & Marketing Function

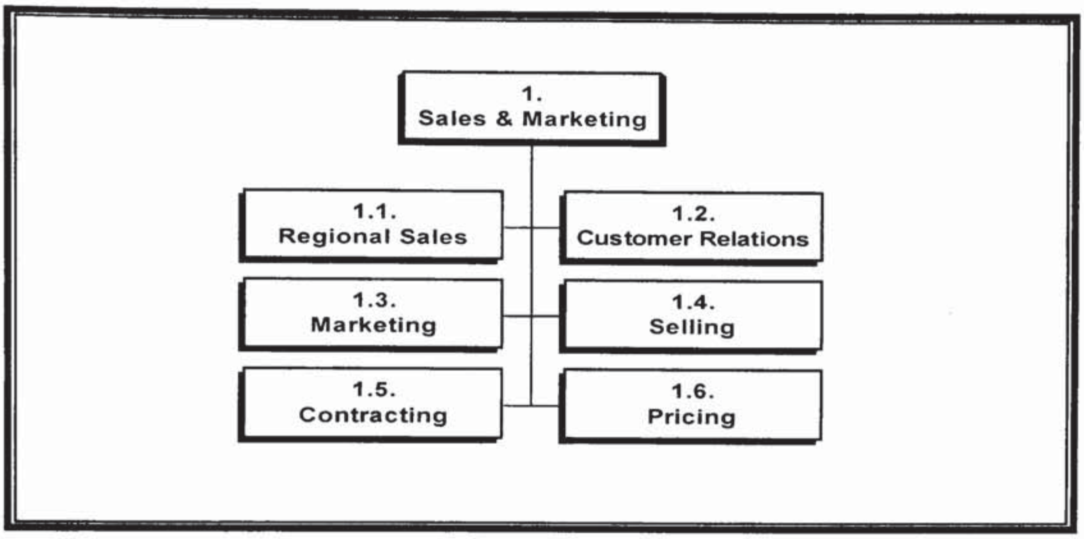


Figure 3 shows the sub-function for Sales and Marketing. Six sub-functions have been identified, namely Regional Sales, Customer Relations, Marketing, Selling, Contracting and Pricing. Each sub-function is further decomposed into second-level sub-functions as shown in figures 3a to 3f below.

Figure 3a. Regional Sales Sub-Function

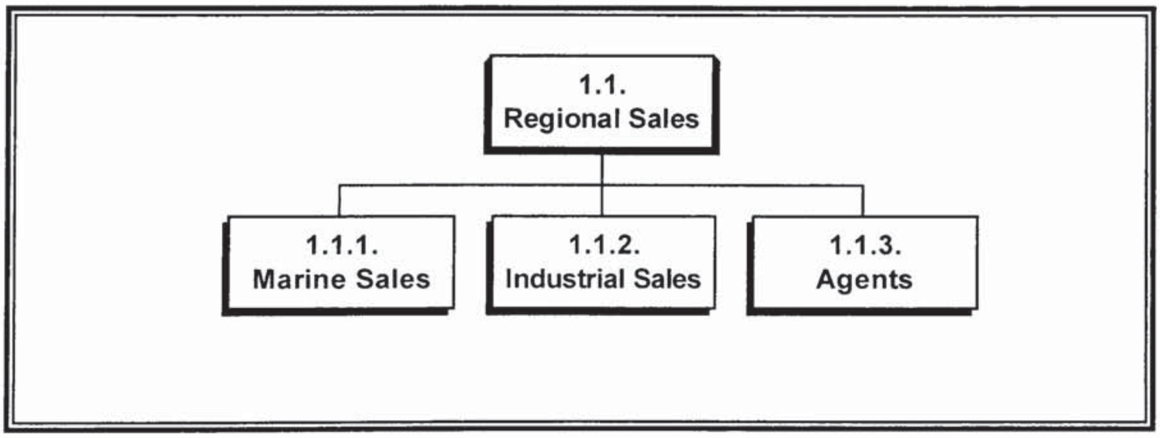


Figure 3b. Customer Relations Sub-Function

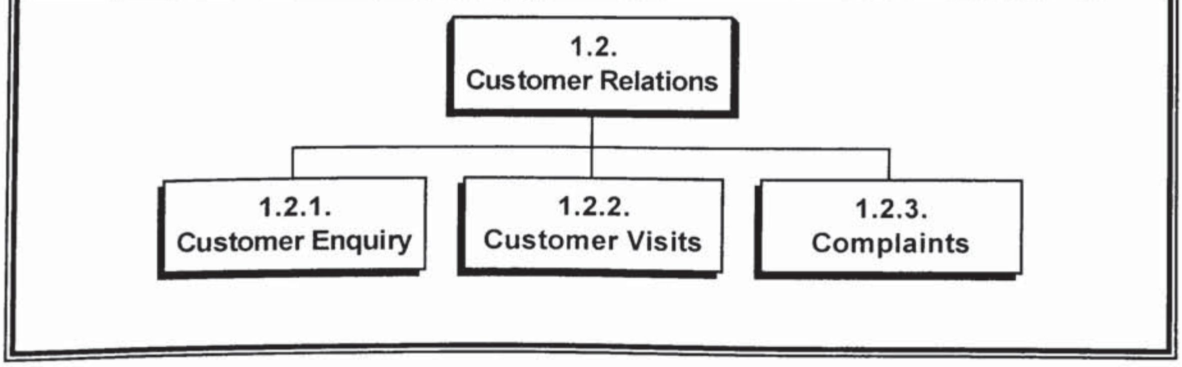


Figure 3c. Marketing Sub-Function

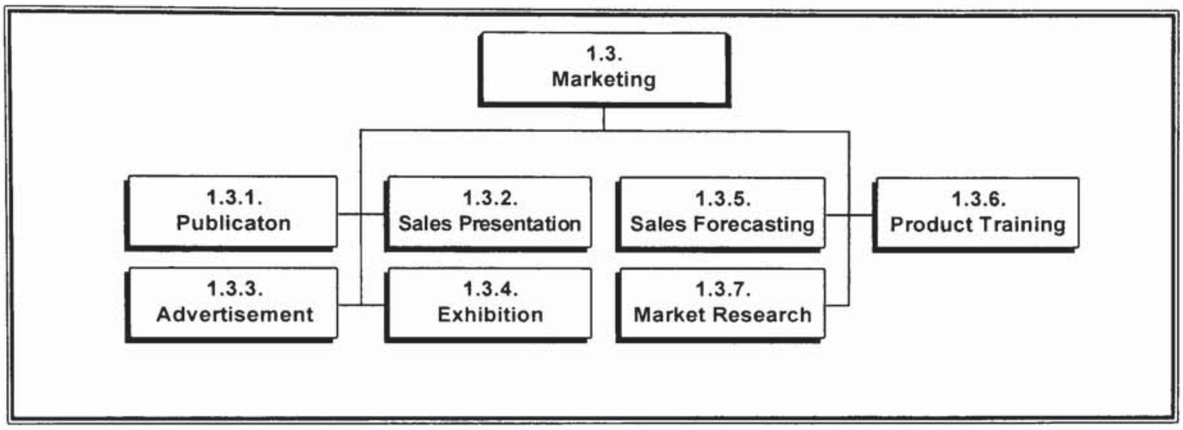


Figure 3d. Selling Sub-Function

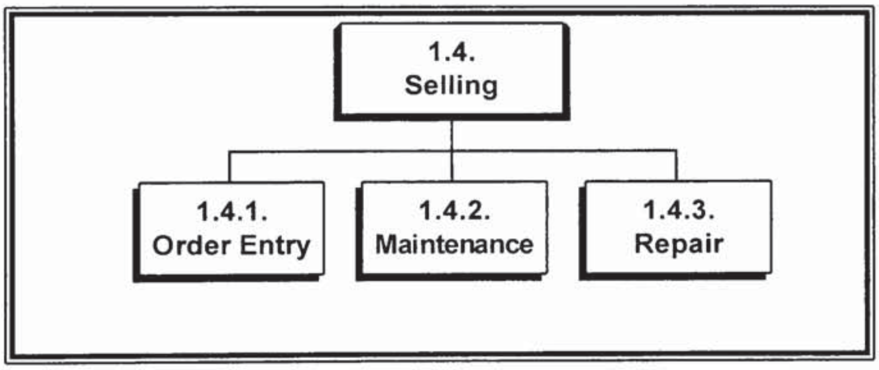


Figure 3e. Contracting Sub-Function

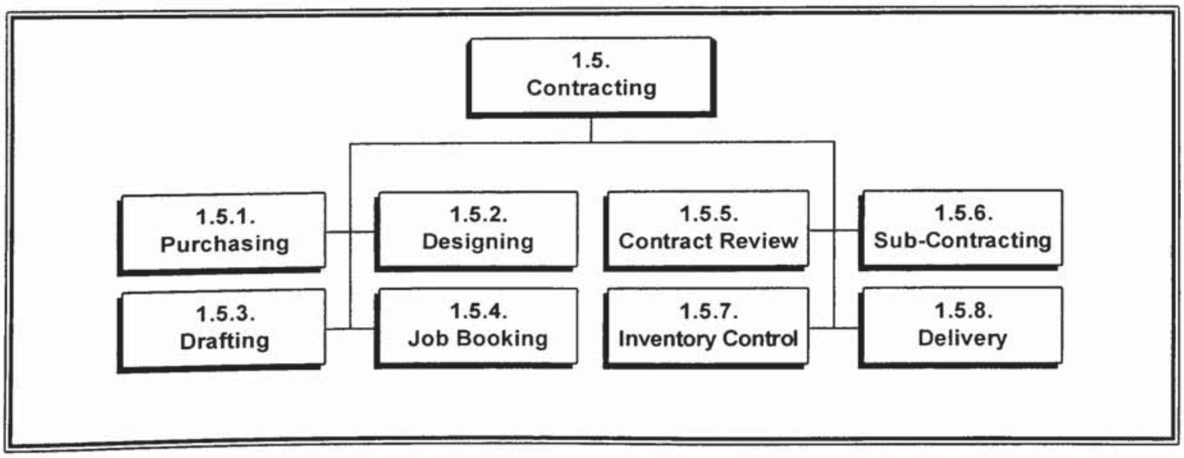


Figure 3f. Pricing Sub-Function

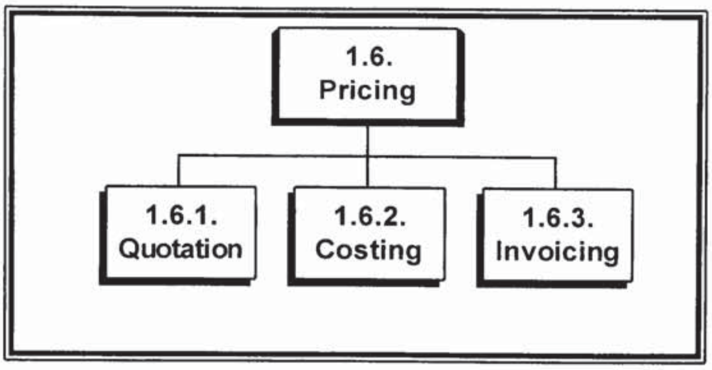
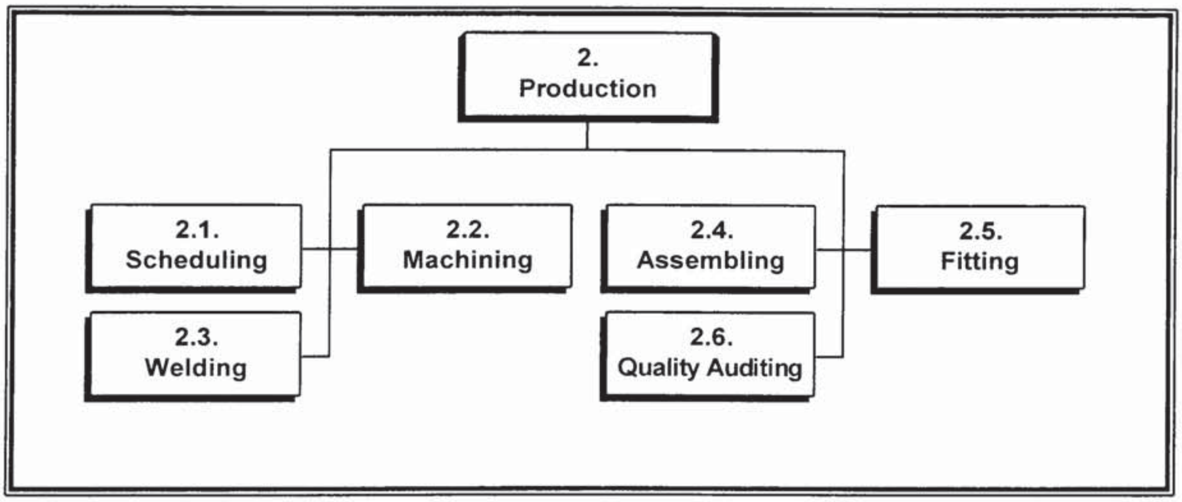


Figure 4 shows the sub-functions for Production. A total of 6 sub-functions made up the production function. These are Scheduling, Machining, Welding, Assembling, Fitting and Quality Auditing. Certain sub-functions are decomposed into lower-level functions whilst others have reached its *primitive* level which require no further decomposition.

Figure 4. The Production Function



Figures 4a through 4c decompose the Scheduling, Machining and Quality Auditing sub-functions into lower-level functions.

Figure 4a. Scheduling Sub-Function

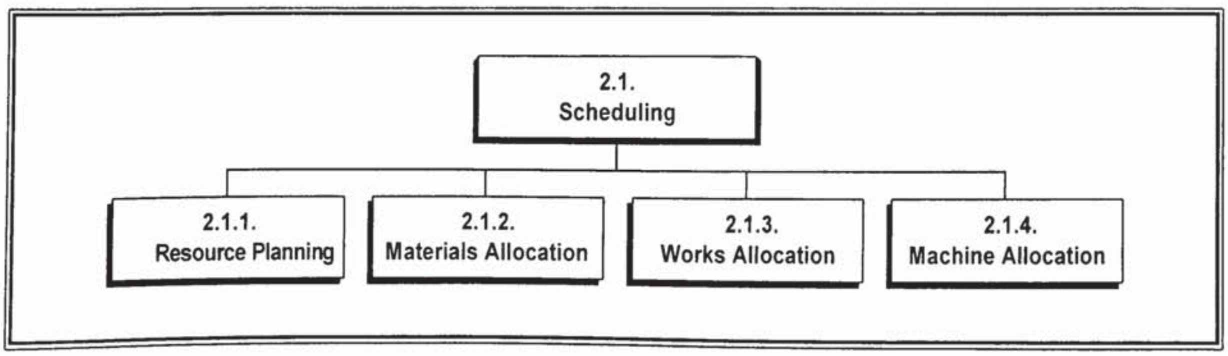


Figure 4b. Machining Sub-Function

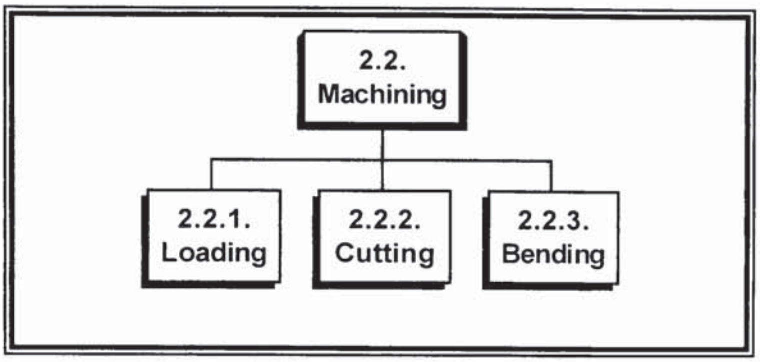


Figure 4c. Quality Auditing Sub-Function

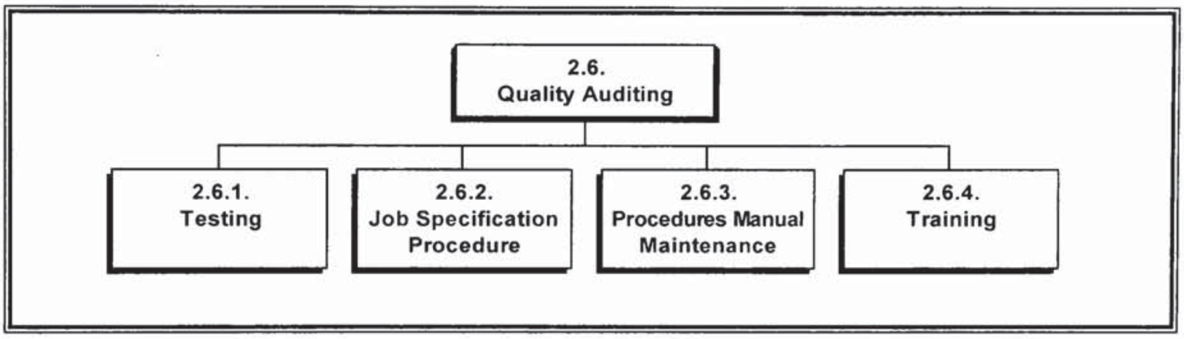


Figure 5 depicts the sub-functions for the Research and Development function. There are 6 sub-functions namely, Machine Development, Component Development, Planning Development, Tool Development, Design and Drawing, and Pressure Fitting.

Figure 5. The Research and Development Function

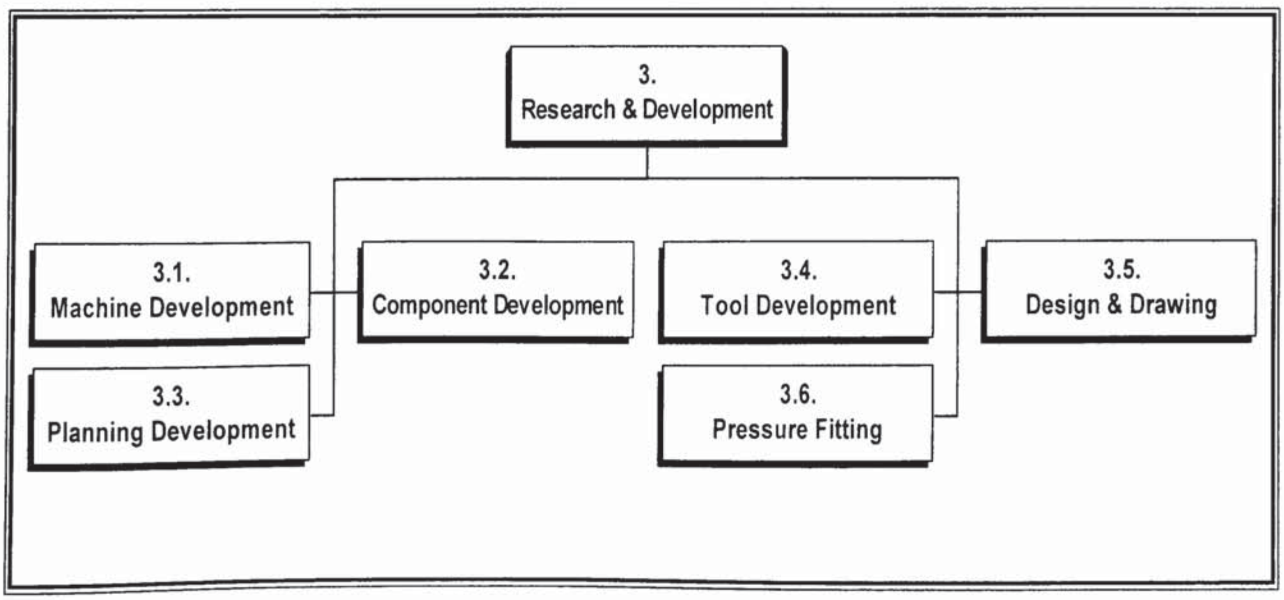


Table 1 below summarises the business objectives of the 3 main functions.

Table 1. Summary of Functional Objectives

Business Function	Functional Objectives
1. Sales & Marketing	• To identify customer's needs and satisfy those needs profitably • Improve product quality • Improve sales profitability • Emphasis on sales over the rail and power generation industries • Accomplish contracts on time and economically • Improve stock holding through Just-in-Time ordering
2. Production	• Produce as much and as quickly as possible with minimum costs • Enhance employee skills to become more productive • Increase production capacity without increase in cost • Improve quality of product • Get work accomplish on time • Ensure products meet customer's requirements • Reduce the number of customer complaints • Minimise or eliminate rejects and re-works • Improve quality systems and procedures • Enhance staff welfare and morale
3. Research & Development	• Expand product range • Use new technology to develop products • Research on developing products economically and efficiently • Introduce IT to improve business activities

3.3 Critical Success Factors and Critical Decisions

Critical Success Factors or CSF can be defined as those few key areas where things must go right for the business to flourish. These could be critical processes or business activities, or critical information that are required where failure in these areas could be disastrous to the business. The purpose of the CSF is to analyse the potential information needs of the respective business functions and to determine whether these needs are supported by the business goals and consistent with the functional objectives.

Table 2 summarises the CSF of the 3 main business functions identified in this study.

Table 2. Critical Success Factors

Business Function	Critical Success Factors
1. Sales & Marketing	• Timeliness - sales to production to dispatch • Access to customer's information • Availability of parts to produce components/products for sales • New, current, potential and outstanding orders • Status of jobs-in-progress at a particular instance • Keep inform about competitors • Communication between departments • Status of stock at any one time

2. Production	• Current and accurate information about incoming contracts • Materials received at acceptable quality standards • Employees sufficiently skilled, trained and right attitude towards tasks • Maintain quality of machines, procedures and tasks • Information on major orders coming in • Reduce/eliminate complaints and rejects
3. Research & Development	• Skilled employees doing development tasks • Clear policy and procedure on development • Better machinery to improve quality and productivity

Critical decisions are important business decisions that will support the CSF. A number of critical decisions have been identified for each business function and are listed in table 3 below. This will ultimately leads to the development of potential decision support systems as tools to aid in the decision making process.

Table 3. Critical Decisions

Business Function	**Critical Decisions**
1. Sales & Marketing	• Determine which customer enquiry to take on • Decide on job request • Determine costing and pricing of particular job • Determine work loads of sales team • Decide on delivery time • Decide on sales and marketing budgets • Determine technical capability to accomplish contract • Decide on acceptance of purchase order • Determine priority of work schedule (job priority) • Decide on purchase of material • Determine subcontract work • Decide on how to dispatch goods • Determine mode of transport for delivery of finished goods • Determine customer credits
2. Production	• Decide on job assignment • Determine suitability of staff to carry out tasks • Determine resources to be allocated for tasks • Determine job priority (prioritising orders) • Determine product quality for acceptance • Determine workshop layout • Determine work schedule • Decide on acceptance of materials • Determine minor changes on re-works • Determine production budgets
3. Research & Development	• Determine machinery and resources for development • Determine R&D budgets • Determine technology for product development • Decide on job assignment • Determine product quality for acceptance • Determine workshop layout

3.4 Analysis of Problems

Britannia as with all other firms is not excluded from having problems. This tends to make it more difficult to achieve the required goals though usually solving a particular problem may actually be a step closer to achieving the goal. This study has recorded a number of problems based on interviews with the respective managers. The aim is to highlight some of these problems which may be critical and may have implications towards meeting the business as well as the operational objectives. During the course of the interviews, respondents have been very open and frank about the issues they faced. When attention is focussed on a particular problem, that problem is more likely to be solved. Furthermore by analysing these problems, certain information systems facilities may be of help as aids towards dealing with these problems.

Table 4 gives a list summary of problems quoted by the management of Britannia. The analysis of the problems includes possible solutions, criticality of solving the problem, the business functions involved and the system or information requirements that deal with the problems.

Criticality is based on a ranking scale 1-5 as follows:

5 = Critical to operation of business and must be rigidly performed (such as mission-critical quality procedures).

4 = Critical to undisrupted operation of business (such as production schedule).

3 = Required to support business (eg. customer enquiry).

2 = Required to support business, however the importance and rigidity of the activity is lower than 3 (eg. regular scheduled reports).

1 = Desirable, but not absolutely required to support business.

3.5 Information Needs

Information needs are identified based on analysis of each functional area requirements and it's CSFs and problems. First-cut broad data subjects representing the highest level overview of Britannia's information needs have been identified. This is represented in the form of a data subject decomposition diagram as in Figure 6.

The data subjects are then expanded to form entity types and a data model representing Britannia's information needs can then be created in the form of an Entity Relationship Model. This model can later be used as the basis for developing the company's database.

The Data Subject Decomposition Diagram provides a complete overall description of the information needs for Britannia. However, it needs to be transformed to a logical database schema for subsequent design. This would require the identification of the underlying attributes and identifiers that made up the entity in order to form the database structure.

Table 4. Problems Analysis

Problem	Solution	Criticality Rating	Inhibits Goals	Caused by Function	Impacts Function	Requires Entity/Systems
1. Lack of initiative (inactivity) to follow up impairs prospective sales	• Employ more staff • Better sales monitoring system	3	• Identify customer's needs & satisfy those needs profitably • Improve sales profitability	• Customer Relations • Marketing • Contracting • Scheduling		• CUSTOMER • PRODUCTION SCHEDULE • Better Scheduling System
2. Lack of communications between departments causing misunderstanding and inaccurate information	• Accurate workshop loading information • Integrated information systems • Better production scheduling system	3	• Accomplish contracts on time and economically • Improve stock holding • Produce as much and as quickly as possible with minimum costs • Increase production capacity without increase in cost • Get work accomplish on time • Ensure product meet customer requirements • Reduce number of customer complaints • Minimise or eliminate rejects and re-works		• Regional Sales • Customer Relations • Marketing • Contracting • Production	• Sales Information Systems • Production Information Systems • SALES • ORDERS • PRODUCTION SCHEDULE • WORK-IN-PROGRESS
3. Inflexible customer and supplier information causing rigid access	• Better cross-referencing of information • Integrated	4	• Identify customer's needs and satisfy those needs profitably • Improve sales profitability		• Sales & Marketing • Productio	• Integrated Customer Information Systems

	information systems		• Accomplish contracts on time and economically • Improve stock holding • Get work accomplish on time • Reduce the number of customer complaints • Introduce IT to improve business activities		n • R&D	• Sales & Purchase Order Processing Systems • Distribution Systems • CUSTOMER • ORDERS • SALES • PURCHASE
4. Users not involved in software development causing requirements not fully met	• Refer to systems development methodology for user involvement	3	• Introduce IT to improve business activities	• R&D		• Systems Development Methodology
5. Works overloaded inhibit motivation and morale	• Employ new staff • Train existing staff	4	• Improve product quality • Accomplish contracts on time and economically • Produce as much and as quickly as possible with minimum costs • Enhance employee skills to become more productive • Increase production capacity without increase in cost • Improve quality of product • Get work accomplish on time		• Regional Sales • Contracti ng	• Project Planning System
6. Too little time on	• Employ new staff	3	• Accomplish contracts on		• Contracti	• Human

managing department inhibits improvement	• Train existing staff • Better time management		time and economically		ng	Resource Information System • STAFF
7. Resistance to change and general management inhibit growth and use of modern technology	• Motivation to use IT • Management techniques	3	• Produce as much and as quickly as possible with minimum costs • Increase production capacity without increase in cost • Introduce IT to improve business activities		• Productio n	• Management Information Systems
8. Lack of understanding among staff causing personality conflict	• Staff motivation	3	• Get work accomplish on time • Improve quality systems and procedures		• Productio n	• Better production scheduling system • PRODUCTIO N SCHEDULE
9. Lack of general motivation for staff inhibits staff growth	• Staff motivation • Better incentive schemes	3	• Enhance staff welfare and morale • Get work accomplish on time • Produce as much and as quickly as possible with minimum costs		• Productio n • R&D	• TRAINING
10. Lack of information on status of orders inhibits efficient Order Processing	• Better system for Order Processing	4	• Improve sales profitability • Accomplish contract on time and economically • Improve stock holding	• Sales & Marketing • Production • R&D		• ORDERS • WORK-IN-PROGRESS • SALES

			• Produce as much as possible with minimum costs • Increase production capacity without increase in cost • Get work accomplish on time • Reduce the number of customer complaints • Minimise or eliminate rejects and re-works • Introduce IT to improve business activities			FORECASTS • Sales Order Processing System
11. Lack of balance between working too much on overtime to increase sales versus increase in labour costs inhibits profitability on sales, better productivity and minimise costs	• Better accounting system • Better sales forecasting system • Better scheduling of resources	4	• Improve sales profitability • Accomplish contracts on time and economically • Produce as much and as quickly as possible with minimum costs • Increase production capacity without increase in costs • Get work accomplish on time		• Sales & Marketing • Production	• Better Sales Forecasting System • Better Production Scheduling System • Better Accounting System • SALES • ORDERS • WORK-IN-PROGRESS • PRODUCTION SCHEDULE • COSTS

						• GENERAL LEDGER • OVERTIME • EMPLOYEE
12. Lack of control on stock inhibits accurate stock holding	• Better Stock Control System	4	• Accomplish contracts on time and economically • Improve stock holding through JIT ordering • Produce as much and as quickly as possible with minimum costs • Increase production capacity without increase in costs • Get work accomplish on time	• Inventory Control • Schedulin g	•	• Stock Control System • Better Distribution Systems • SUPPLIER • PURCHASE ORDER • MATERIAL • PARTS • BILL OF MATERIALS • ACCOUNTS PAYABLE •
13. Lack of information on internal re-works inhibits progress and status of jobs	• Better sharing of information between various people involved in the re-work	3	• Improve product quality • Get work accomplish on time • Ensure products meet customer's requirements • Reduce the number of customer complaints • Minimise or eliminate rejects and re-works		• Scheduli ng • Quality Auditing	• RE-WORK • PRODUCTIO N SCHEDULIN G • JOB

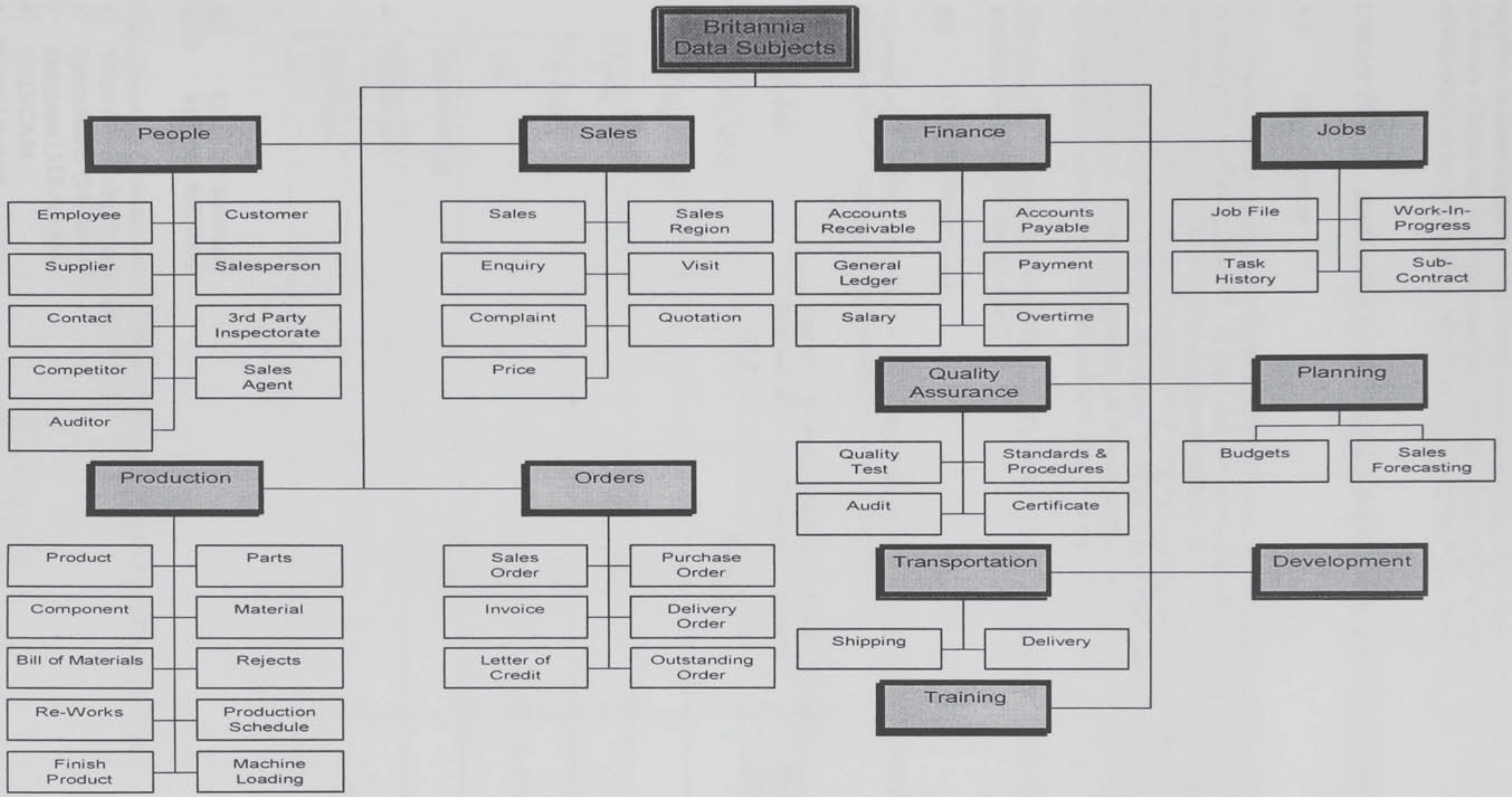


Figure 6. Data Subjects Decomposition Diagram

As described previously the lower level business functions are used to cluster the entity types together to form business areas where potential applications can be developed. For this purpose an Entity Clustering Algorithm has been developed to implement the Affinity Analysis. Results of this analysis are presented in the IT Strategy section of this report.

CHAPTER 4. INFORMATION TECHNOLOGY ENVIRONMENT

4.1 Introduction

As with most other small firms, Britannia has no formal information systems structure and no dedicated IT staff to support IT. IT has been use ever since the company started with the first installation of a PC (IBM PC AT) and subsequently an in-house invoice printing application was developed. In 1994 with an IT investment of £25,000 several more PCs (386s) were bought and a Local Area Network (LAN) was installed to facilitate information sharing and access to a common database. There are currently 18 PCs connected within the LAN and these are linked to the Internet for electronic communication with the outside world.

The General Manager R&D assumes the responsibility for the company's IT and carries out the systems development work himself.

4.2 Current Hardware

Acquisition of the PCs was done in stages according to the needs at the time. The PCs are distributed to the various departments as shown in Table 5 below.

Table 5. Computer Hardware and Printers

Location	Number of PCs	Type of Computer	Number of Printers
MD's Office	1	Laptop	
Administration	2	386	1
Sales	3	386	1
Contracts	3	386	1
QA	1	386	1
Development	2	Pentium 386	1
Production	4	386	
Accounts	2	386	1

4.3 Current Software

4.3.1 Systems Software

The Operating Systems used is Windows NT. Other systems software include:

- Word Processing System (MS-Word)
- Spreadsheet (MS-Excel)
- Database (MS-Access)
- CAD/CAM
- E-mail system
- Internet
- DTP
- Graphics

4.3.2 Application Software

Applications are mainly developed in-house. The development tools used to developed most of these applications are MS-Access, Visual Basic and MS-Excel. A list of the applications is shown in Table 6 below.

Table 6. List of Application Software

Application	**Usage** (currently using,upgrading,developing)	**Source** (package,in-house,3rd party)
Accounting Systems	Currently using	Package
Contracts	Currently using	In-house
Credit Control	Currently using	In-house
Customer Enquiry	Currently using	In-house
Engineering Autocad	Currently using	In-house
Fixed Asset	Currently using	In-house
Sales Forecasting	Currently using	In-house
Invoice & Billing systems	Currently using	In-house
Material Control	Currently using	In-house
Personnel System	Currently using	In-house
Purchase Order Processing	Upgrading	In-house
Sales Order Processing	Upgrading	In-house
Stock Control System	Developing	In-house

The Sales Order and Purchase Order Processing Systems are currently being upgraded to replace the older version that has been used since 1994. This upgraded version will become the company's main application that will eventually be integrated with all other applications. For a start a stock control system is currently being developed to replace the existing systems used separately by 2 departments. The new system will be integrated with the new order processing systems.

4.4 Information Systems Organisation

As mentioned earlier Britannia has no formal IS organisation. However, the GM R&D assumes the overall responsibility for IT adoption as well as making decisions on purchases and determines policies and procedures for the use of IT. Overall, members of the management are very receptive to IT and all managers have access to PCs. Studies have shown that top management support is important for IS success particularly in small firms. A positive attitude towards IT is also critical for increased sophistication in the use of IT. Britannia has the right characteristics for IT success as evidenced by the majority of the managers interviewed having positive attitudes toward IT.

With the absence of professional IT staff, users are resorting to end-user computing in a controlled manner. Few key staff are authorised to develop applications for their own use as well as for company-wide applications. Example of individual application is the Stock Control system for the Contracts Department whilst the Order Processing systems are being developed across all functional areas. Other users may develop queries to retrieve information from existing databases to facilitate individual work without compromising on data integrity and duplications.

CHAPTER 5. INFORMATION TECHNOLOGY STRATEGY

5.1 Information Systems Strategy

Britannia's business mission and strategies highlight the importance of the people, the product and the process aspects of the business. Foremost within the people aspect is the customer, an external entity that keeps the company in business. Equally critical is the internal entity, employee that ensure the company is operating effectively and most importantly meeting the needs of the customer.

To ensure the effectiveness of Britannia's information systems plan, the company's strategic information has to be closely aligned to its strategic business objectives. The implementation of this information system strategy has to take into account the company's business strategy so that the priority of developing information system applications will be based on the company's business strategies. Based on the analysis that has been done, a number of information systems applications have been identified that would satisfy these needs. These applications are formed as a result of performing *Affinity Analysis* associating Britannia's business functions with its information needs. Appendix I shows the association matrix mapping business functions with information needs (entities). A "C" in each cell indicates a function that creates the corresponding entity (ie. source of information), and a tick mark (3) denotes the function uses the corresponding entity as "read-only" access (ie. no capability of creating, updating or deleting). It is assumed that a function that creates an entity can also update and delete that entity.

The associated matrix in Appendix I constituted the input for the Entity Clustering Algorithm which is a major procedure within the Affinity Analysis. A computer program was written in Ada to implement the Affinity Analysis. The matrix defined the relationship between the 48 functions and the 59 entities. A relationship between a function and an entity exists if the function uses the entity in its execution. The algorithm will compute Affinity Factors, which represent the proportion of the number of Functions using a pair of entities out of the number of Functions using one element of the pair. Entities with high affinity factors with a given entity will be grouped together to form an entity cluster. This is repeated for all combinations of entities. Affinity analysis is also performed on a set of defined parameters. In order to ensure consistency in the analysis, a combination of thresholds were fitted into the program and a trend is identified. This simulation revealed that there were entities that always belong to a cluster, while other entities moved among the clusters with different thresholds. The aim is to identify the best patterns that fit these entities. Results of the affinity analysis are included in appendix 2.

The analysis yields 17 clusters utilising all 59 entities. These clusters are then examined for similarity in their characteristics to form into groups representing potential business areas. A miscellaneous group was formed comprising numerous and varied entity types that constantly moved between clusters when different thresholds were applied. Because of this the miscellaneous group is not considered potential business area but some of the entities are taken out and included in the existing cluster that mostly represents those entities. However this does not mean the remaining entities are not important to Britannia. They merely indicate that their associations with the other entities are weak which could be due to 2 reasons. Firstly they exist in isolation and therefore not significant information needs to Britannia and secondly their associations are not well documented in the initial analysis due to lack of information.

Table 7 below shows the summary of the potential business area classification based on the analysis. Basically, 12 business areas have been identified with each revealing their own distinct characteristics as a result of the cluster groupings.

Table 7. Business Area Classification for Britannia Heat Transfer Ltd.

Business Area	Entity Type	Cluster
1. Product Information	Product Component	1

2. Personnel	Employee Department Staff Training Skill Job	2 14
3. Inventory	Machine Tool Parts Materials Bill of Materials Machine Load	3 4
4. Customer Information	Enquiry Visit Site Customer	5
5. Delivery	Packing Notes Destination Carrier Invoice Delivery Finished Product	6
6. Contract	Job File Sub-Contract Contract	4 7
7. Financial	Receivable Payable Payment Financial Salary Overtime Budget	1 8 13 15
8. Order Processing	Outstanding Order Sales Order Supplier Purchase Order	9 15
9. Sales	Sales Competitor Sales Training Commission Complaints Quotation Cost Price Sales Agent Sales Region	5 10 16
10. Production	Work-in-Progress Re-Work Task History Production Schedule Reject	11
11. Quality Assurance	Audit 3rd Party Inspectorate	12

	Quality Test Quality Standards Certificate	
12. New Product Development	Development New Products	17
13. Miscellaneous	Patent	10

Each business area identified consists of entities that are closely related that would result in the formation of several applications accessing the same data sources. For each business area an application portfolio is formed to analyse the information strategy by dividing the applications into one of 4 priority areas. These are (1) *Strategic*; (2) *Operational*; (3) *Potential*; and (4) *Support*. *Strategic* applications are those that are critical to the future success of the business. Applications that are closely related to supporting the company's mission and business goals should belong to this category. Applications in the *Operational* category are those that are critical in supporting the day-to-day business activities. Their development should be given top priority. Whereas *Potential* applications are those that will move to the *Strategic* category depending on availability of technology and resources. Applications that belong to the *Support* category are those that can facilitate and improve the management and activities of the business area.

A description of each proposed business area and its underlying application portfolios is presented next.

a) Product Information

The Product Information business area was formed based on the clustering of 2 entities, namely Product and Component, which was the first cluster created by the Affinity Analysis clustering algorithm. Incidentally, the two entities have a perfect affinity association that verifies the clustering.

The information strategy for this business area is to develop a Product and Component database application that will be integrated with other applications accessing the product and component information. This application should be used to create information on new products and components, and to maintain existing products and components information. The application portfolio of Table 7a categorised this application as *Operational*.

Table 7a. Application Portfolio for Product Information Business Area

STRATEGIC	POTENTIAL
OPERATIONAL • Product and Component Database Application	**SUPPORT**

b) Personnel

Staff welfare has been identified to be strategic to Britannia. As the company expands, more staff would be recruited and an effective management of human resource would be much needed. An integrated Human Resource Information Systems should cater for the needs of human resource planning, staffing, staff development, skills, rewards and compensation, performance and appraisals, legal, health and safety, and employee assistance. Obviously a formal Information Systems structure would be needed to support and maintain such systems. Table 7b categorised the Human Resource Information Systems under the *Potential* category.

Based on existing requirement, 3 personnel applications are identified in the *Support* category. A personnel database application should be developed to maintain personnel records, which can also be accessed by other applications such as payroll and production scheduling. Staff Training and Skill Inventory should also be developed as part of supporting the personnel management. These applications should later be upgraded and their data migrated to the Human Resource Information Systems.

Table 7b. Application Portfolio for the Personnel Business Area.

STRATEGIC	POTENTIAL
	Human Resource Information System
OPERATIONAL	**SUPPORT**
	Personnel Database Application Staff Training Skill Inventory

c) Inventory

This business area is formed to provide an information strategy for effective management and control of equipment and materials to ensure a smooth and efficient production operation. An integrated Inventory Control system and the Bill of Materials application should be developed to support the business strategy of providing Just-in-Time delivery and optimal utilisation of materials and resources. These applications are critical to the operation of the business and their development should be given priority. As such they are placed within the *Operational* category as in Table 7c. Links should also be provided to integrate with the Order Processing system, the Supplier database application, and the Delivery system to form a complete Distribution System. External links to selected suppliers should also be considered for automatic re-ordering and replenishment of stocks and materials.

Table 7c. Application Portfolio for the Inventory Business Area

STRATEGIC	POTENTIAL
	Interface Triggers to Suppliers
OPERATIONAL	**SUPPORT**
Inventory Control Bill of Materials	

d) Customer Information

Table 7d shows the application portfolio for the Customer Information business area. The development of a Customer Database could be considered strategic, as customer information is critical and central to Britannia. Other applications may access the customer database as read-only and any updates or maintenance on customer information should be done using the Customer Database application.

Table 7d. Application Portfolio for Customer Information Business Area

STRATEGIC	POTENTIAL
Customer Database	
OPERATIONAL	**SUPPORT**
Enquiry System	Ad-hoc queries Appointment System

The *Operational* category includes an Enquiry System that is a front-end application supporting customer and potential customer queries. This system should be built on several modules each grouped into common subject based on past query experience. Other applications such as Ad-hoc queries and an Appointment System are categorised as *Support* as they could help to increase the efficiency of the Customer Information business area. To cater for the development of the Ad-hoc queries, a simple and systematic training in end-user computing should be given to all users. This training should focus on developing simple query to access the customer database and other information. The aim is to release some of the burden of the development team by letting users to develop their own queries to satisfy their information needs.

e) Delivery

Five applications are identified within this business area. A Delivery system would be helpful to track the delivery and distribution of the finished products to customer sites. Information regarding the transportation and shipping companies should also be included. The other applications are printing of Invoice, Delivery Order and Packing Notes, which can be generated based on information processed within the Order Processing business area. A fifth application, an Electronic Data Interchange (EDI) would be helpful to facilitate export documents and Customs. This application should be considered when Britannia has the necessary support resources particularly in the telecommunication area as the majority of the problems encountered in the implementation of EDI involve telecommunication and network. Table 7e summarised the application portfolio within the Delivery business area.

Table 7e. Application Portfolio for the Delivery Business Area

STRATEGIC	POTENTIAL
	Electronic Data Interchange
OPERATIONAL	**SUPPORT**
Invoice Delivery Order Packing Notes	Delivery System

f) Contract

Table 7f shows the application portfolio for the Contract business area. Three applications have been identified to support this business area. A Job Booking application should be developed to book jobs and create job files which would then be accessed by the Production Scheduling system for resource planning and scheduling. The application is categorised as *Operational* as it could facilitate the management of production resources which is crucial for effective production scheduling and operations.

Table 7f. Application Portfolio for the Contract Business Area

STRATEGIC	POTENTIAL
OPERATIONAL	**SUPPORT**
Job Booking Application	Contract Specification Database Sub-Contract Application

Developing a Contract Specification database would be beneficial to facilitate referencing and cross-referencing multitude of technical drawings in a particular contract work. A Sub-Contract application should also be considered to manage and monitor sub-contract activities.

g) Financial

In the analysis of this business area, there was a difficulty to determine the entity cluster grouping. Varied cluster patterns were formed each time different threshold values were fitted into the Affinity Analysis algorithm. This may be due to the lack of information received from the finance and accounting activities as no specific interview was done on this area. However, most of the entities in this business area were picked from the miscellaneous group and originated from 4 different clusters. Though the information requirements may be incomplete, standard applications have already existed in the finance and accounting areas. Examples include the General Ledger, Accounts Receivable and Payable, Debtors and Creditors, Bank Reconciliation, Budgetary system, and Payroll application.

Within the context of a small business like Britannia, minimum finance and accounting activities may not justify the development of the Financial and Accounting applications. However, for effective management of the company's assets and liabilities, a viable information strategy for this business area is to initially categorise these applications under the *Support* category. It will be beneficial at this time to acquire off-the-shelf packages to meet the requirements of this business area.

h) Order Processing

This business area has also been identified as strategic to Britannia's business. Efficient and effective order processing directly impacts the company's mission and goals. As described previously, the Sales Order and Purchase Order Processing Systems are currently being developed. These systems should also be integrated with other applications such as the Inventory Control System, Bill of Materials, Customer Information System, Supplier Database, Sales and Purchasing applications.

The application portfolio for the Order Processing business area is shown in Table 7h below.

Table 7h. Application Portfolio for Order Processing Business Area

STRATEGIC	POTENTIAL
Sales Order Processing System Purchase Order Processing System	
OPERATIONAL	**SUPPORT**
	Order Information System Supplier Database Application

Two other applications included in the *Support* category are the Order Information System to monitor outstanding orders, and a Supplier Database Application. Apart from information regarding suppliers, a rating system may also be incorporated to identify "good" suppliers according to combinations of quality, delivery, price, service, etc.

i) Sales

Eight applications have been identified to support the Sales business area. A model can be developed and implemented in an electronic spreadsheet for sales forecasting. Past sales data can be used as input to the model and different values can be fitted to examine sales trends and generate "what-ifs" scenarios. This can later be extended to form a Sales Decision Support System that links to other databases to analyse the necessary data and information as an aid for making sales decisions. For example the Sales DSS can be used to generate alternative scenarios if a new sales is accepted showing the implications to materials and other resources, its impact on the existing jobs, production schedules and operations, and the company's profitability. The Sales Forecasting application is categorised as *Strategic* whilst the Sales DSS could be *Potential* as shown in table 7i.

Table 7i. Application Portfolio for the Sales Business Area

STRATEGIC	POTENTIAL
Sales Forecasting	Sales Decision Support System
OPERATIONAL	**SUPPORT**
Pricing Application Quotation printing Account Maintenance Application	Complaints Application Agents Database Application Competitor Information

Applications in the *Operational* category include Pricing application, printing of Quotation, and an Account Maintenance application. This latter application can be used to maintain and monitor sales activities for a given account under the responsibility of a salesperson.

Applications contain in the *Support* category include recording and analysis of complaints, Agents database, and maintaining Competitor information. The Complaints application should include cross-analysis of different types of complaints, complaint ratings, frequency of occurrence, sources, and actions taken. With the Internet facility links could be created to establish a network of agents where information could be disseminated electronically world-wide in a matter of seconds. Internet linkages to other firm's home pages could also be established for information on competitors.

j) Production

The Production business area includes those applications supporting the production operations. These include the Production Scheduling System, a Work-in-Progress application, and a Capacity Planning application. These applications are not only critical to the production business area but also to other business areas and should be considered mission-critical. As such they should be categorised as *Operational* and their development should be given priority. However, a quick alternative to this is to acquire a Material Requirements Planning (MRP) system whose components include the 3 applications mentioned above and inputs from the Inventory system, Bill of Materials, and the Order Processing System developed within the Inventory and Order Processing business areas. If this option is chosen, the MRP system should be categorised as *Strategic* as opposed to *Potential* due to its importance and criticality to the business.

Table 7j shows the application portfolio for the Production business area. Other supporting applications may include details of tasks performed on specific jobs for archive purposes, and a database application to maintain information on products and components that require re-works and/or were rejected for quality reasons.

Table 7j. Application Portfolio for the Production Business Area

STRATEGIC	POTENTIAL
MRP System	
OPERATIONAL	**SUPPORT**
Production Scheduling System Work-in-Progress Application Capacity Planning Application	Tasks Archive Re-work and Reject Database Application

k) Quality Assurance

A number of applications have been identified to support the Quality Assurance business area. The application portfolio to analyse each application strategy is shown in Table 7k below.

Table 7k. Application Portfolio for Quality Assurance Business Area

STRATEGIC	POTENTIAL
Quality System	
OPERATIONAL	**SUPPORT**
Audit System	Certificate Prints

Quality System has been identified as a business strategy for Britannia and is closely related to the company's mission and strategic goals. Quality System includes quality standards and procedures, and quality tests. It is therefore important that the development of a Quality Information System application be planned and developed.

The *Operational* category consists of the Audit application, whilst the Printing of Certificate is included under the *Support* category.

l) New Product Development

This business area includes applications that creates information on new product design, maintains products and components specifications, and updates statuses of new products and components development in progress. Though the business function responsible for this business area is critical for the company's continued and sustained growth, the applications that are identified to support this business area are not mission-critical and therefore they are categorised as *Support* applications. Table 7*l* lists the 3 main applications in this business area.

Table 7*l*. Application Portfolio for New Product Development Business Area

STRATEGIC	POTENTIAL
OPERATIONAL	**SUPPORT** New Product Design Specification Product Maintenance Specification New Product Development

5.2 **Information Systems Organisation Strategy**

As more opportunities are now available for businesses to adopt IT, IT has inadvertently become a change agent to influence the way the business operates. However, the benefits derived from the technology can only be achieved through proper planning and placement of the appropriate IT infrastructure. Otherwise the adoption of IT will become a new burden for the organisation resulting in high costs of investment and inappropriate use of IT human resources.

The information system strategy documented in this report is aimed at addressing this in order to meet Britannia's information requirements that are becoming more complex. Relying on an informal IS function is no longer appropriate and practical for a company that is expanding its IT investment. Currently all departments within Britannia have computers with access facility to a network file server. With the development of more applications and acquisition of packages, a formal and organised IT administration is appropriate and should be considered with the main aim of providing a company-wide co-ordination and compatibility of hardware and software. In addition, this will also help ensure the effectiveness of future implementation of Britannia information systems.

A unit called **Information Systems Office** (ISO) should be established and placed under the responsibility of the Development Department. This is consistent with the department's own business strategy to promote the use of IT company-wide. Furthermore the Development Department has the tradition in IT and other technology development and it is only appropriate to formalise the IS structure here. However most IS literature suggests that an IS organisation should be located at the highest level possible to reflect the importance of IT to the whole organisation, and more importantly to ward off any influence a particular department or division has over IT policy and implementation.

The strategy for the ISO organisation includes identifying specific functions to support Britannia's IS implementation, the roles and responsibilities of the functions, and IT human resource requirements. It is suggested that an IT Steering Committee be formed comprising senior members of the management acting as an advisory body that determines IT policies and IS implementation strategies. This committee should be chaired by the MD himself and the ISO manager as its secretariat.

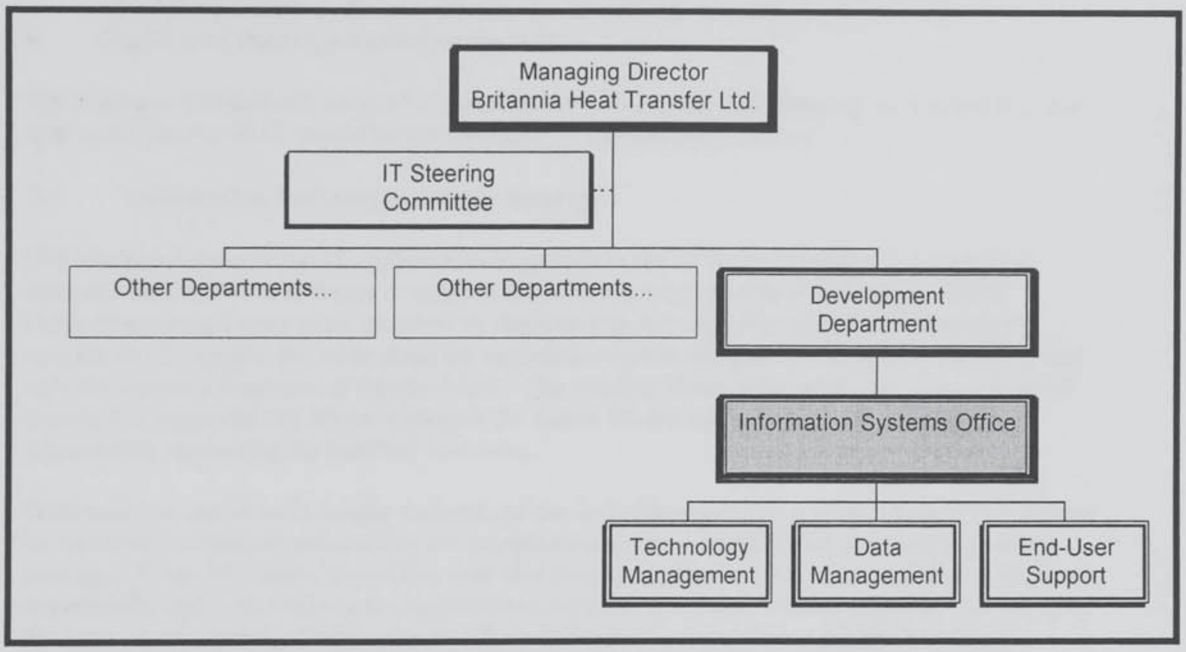
Organisation Structure of the ISO

The Information Systems Office will be headed by a manager responsible for IT planning, developing IS strategy, and implementing Britannia's information systems in accordance with the directions as laid out by the IT Steering Committee. This should represent user requirements

endorsed by the top-level management. Basically, 3 main functions have been identified to support this responsibility. These are:
1. Technology management
2. Data Management
3. End-user support

The organisation structure of the ISO is shown in Figure 7 below.

Figure 7. Organisation Structure of the Information Systems Office



The aims of the Technology Management function are to develop and manage Britannia's IT infrastructure. Among its responsibilities include:
- Oversee the installation and operation of the company's computer equipment.
- Provide technical support for installation of systems software and packages.
- Oversee the installation and operation of telecommunication network and cabling requirements.
- Prepare a technology plan to organise, monitor and implement IT standards and policies based on guidelines by the IT Steering Committee.
- Develop software applications using a standard programming language and other fourth generation language application development tools.

This function should be supported by personnel with a technical background trained in IT preferably in computer science, electronic engineering and/or communication network.

The Data Management function manages data and information produced by the applications for managing the company's information system. Its responsibilities include:
- Provide support for IS projects involving the development and implementation of databases and database application development.
- Create, develop and maintain database structures and data dictionary as a centralise repository of data resources.
- Perform daily database management systems (DBMS) operations that include determining control procedures, security, access rights, fallback, and backup and recovery.

- Assist in systems analysis and other programming tasks in application development. May also assist in end-user development under the co-ordination of the End-User Support function.

This function should be supported by a Database Administrator or an analyst who has a working knowledge in database design and administration.

End-User Support provides support services to all users as part of the company's effort to promote the use of IT. Basically, this function is responsible for:

- As a link between the users and ISO to address problems associated with the use of IT facilities. This include providing *help-desk* services to co-ordinate problems and *trouble-shooting* activities including liaison with vendors.
- Assist in the preparation of MIS reports and other printing materials to the management and end-users. This may also be extended to Britannia's agents and clients.
- Provide consultation and advisory services to end-users in connection with the administration and monitoring of end-user computing policies and procedures.
- Organise IT training programmes for staff.

The Manager ISO himself, or an IT Administrator with a good understanding of the business and with some interest in IT should be the candidate to support this function.

5.3 **Information Technology Supply Strategy**

The implementation of the IS applications suggested in the IS Strategy section would require adequate hardware and software to support the business requirements of Britannia. These applications would need to be accessed by departments and units responsible for their daily operations. To enable this to be done the organisation units of figure 1 will need to be associated with the business functions of figures 2 to 5. The result of these associations is a usage matrix as depicted in Appendix III, whilst Appendix IV shows the association matrix representing applications supporting the business functions.

Both matrices can be used to map the applications with the organisation units. Appendix V shows the applications that are accessed by the organisation units as derived from the mapping of the matrices. From this matrix it could be seen that certain applications are used by a large number of departments and units whilst some applications are used by smaller number of units. This forms the basis of determining the quantity and types of hardware and software needed to support Britannia's business activities. Figure 8 summarises the distribution of hardware among the organisation units.

As shown in Figure 8, two file servers are required to store the databases and the shared applications. One of the file servers should be a mirror image of the other and should be placed in different locations for security and disaster recovery purposes. To facilitate sharing of printing resources, two printer servers should be linked to the network and possibly segmented to cover certain departments for optimal use and minimised network congestion. A total of 20 PCs are required to support user access to the applications. This is an increase of 2 additional PCs from the present 18, to cater for the application development and IS management tasks as a result of forming the Information Systems Office.

Figure 8 also shows the minimum hardware requirements needed to support the initial development and implementation of the applications suggested earlier. As more systems are put in place and application usage increases bigger capacity and high performance servers would be required. In addition, as the company expands and more people are employed, more PCs will need to be acquired to support the number of users.

The high degree of IT resource sharing across the departments implies that there is a high sharing of applications and data among the departments. With the distributed computing resources, part of the IT Supply strategy is to create an integrated communication network system. The existing network system within Britannia may be enhanced to cover all the departments to facilitate sharing of the computing resources.

Figure 8. Distribution of Hardware to Organisation Units

Organisation Units	File Server	Printer Server	PC Client	Local Printer
MD's Office			1	1
Development Department	1	1	4	3
Sales and Marketing Department			3	1
Works Department			4	
Contracts Department			3	1
QA Department			1	1
Administration	1	1	2	1
Accounts			2	1
Totals	2	2	20	9

APPENDIX 5: INFORMATION TECHNOLOGY RESEARCH REPORT FOR UNIVERSAL STEEL TUBE COMPANY LTD.

CHAPTER 1. INTRODUCTION

1.1 Background. *A need for an Information Systems Strategy.*

Organisations, whether large or small, should have the capability to process their own data and use information effectively to be able to compete and become successful. This is especially true in today's fast changing environment, which would require equally fast access to information to cope with the rapid change. Information is used on a daily basis to perform such functions as planning, control, organising and decision-making. Thus, information is a critical resource for an organisation like Universal Steel Tube Company. Any means to assist the company to process and manage information whether mechanical or otherwise should be sought.

During the 1980s, a lot has been said regarding the need for organisations to adopt a strategic approach to manage investment in information systems and technology. In fact, in the late 80s and early 90s, organisations begun to pay more attention on information systems strategy - an organisation's plan to acquire appropriate IT infrastructure such as the supply of suitable hardware, software and telecommunication facilities for the utilisation of applications required by the business with adequate support structure. There were 2 main reasons for this approach.

Firstly, as most organisations were facing one of the worse recessions in the 1980s, majority of their investment has failed to obtain expected returns. This has made the organisations reluctant to spent on IT as they may not achieve the return on their IT investment as expected. Secondly, on the other hand, the use of information systems (IS) by several innovative firms proved that they can achieve competitive advantage. This shows that the use of IS has strategic benefits for these firms. In both of these, IS has become a critical business issue, that is to ensure it is used fully to achieve maximum benefits.

Without the necessary strategy for IS investment several problems may arise, which include:

- Lost of business opportunities, where the business fails to compete because of the use of IS by other organisations. The investment on systems and technology fail to support the business objectives and may become a constraint for further development of the business;
- Lack of integration between systems and data management could result in duplication of efforts, lack of data integrity, inaccurate information, obsolete information, and inadequate information to manage the business;
- IS priorities not based on business requirement, which could result in under-utilisation of resources, and planning for projects that are constantly changing. This will affect business performance, increased in cost, low quality products, and decrease in IS productivity;
- Inconsistent IT strategy, incompatible solutions and lots of money will be wasted in efforts to correct the situation; and
- Lack of understanding and directions between users of IS and top management, as well as those responsible for IS development. This may result in conflicts, inappropriate solutions, and misuse of resources.

The above problems may arise as a result of failure by organisations to plan for their IS in a strategic manner. That is adopting an IS planning approach based on the organisation's business requirement and making IS strategy as part of the organisation's business planning process.

Realising the importance of an IS strategy for the company, the top management of Universal Steel Tube Company (Universal) has agreed that an IT research on IS strategy be conducted and the result of the study is documented in this report. The research is part of a case study investigation to explain a specific IS issue namely the End-User Computing phenomenon within the context of small business. A separate analysis will be done to examine End-User Computing sophistication and an attempt will be made to formulate a viable strategy for End-User Computing within the specificity of small business. With an IS strategy in place, implementing an End-User Computing strategy will benefit many small firms, including Universal, which are currently adopting IT but lacked the technical expertise to develop their own application.

1.2 Objective of the Study

This study aims to formulate an IS strategy for Universal by developing a high-level overview model of the enterprise's information requirements. This overview model is an initial attempt to create an *information architecture* for Universal and this can only be made possible by taking into consideration the company's mission, business goals and objectives, business functions, human resource requirements, current investment, and current and future IT resources.

1.3 Target of Study

The main target of this study is to support the business objectives of the management of Universal. The study begun by analysing the corporate mission and Universal's future direction by adopting a top-down approach in Universal's organisation structure. From here strategic goals of the organisation will be identified together with determining those key areas where things must go right for the business, better known as critical success factors. Next, a top overview of the organisation, functional requirements, data and information needs of key personnel will be identified to ensure that the IS strategy is aligned to the company's business needs. In this context, the management of Universal through the outcome of this study would be able to identify information that are required to support their objectives, functions and critical success factors in a more effective way. Targets of this study include:

- A suite of application portfolio and potential end-user development
- Formation of a corporate database
- Technical environment including hardware, software and networking
- Organisation of information system

1.4 Deliverables

Among the deliverables of this study are as follows:

- This report
- Statements of Universal's information requirement
- Strategies for the adoption of IT that could potentially increase business performance and enhance Universal's services
- Realistic planning to achieve the above targets

1.5 Methodology

The methodology used in this study is based on a structured development approach known as *Information Engineering*. As described by James Martin, Information Engineering is a systems development methodology that applies structured techniques to the enterprise (firm) as a whole or to certain major segment of the enterprise. Information Engineering progresses in a top-down manner through four basic levels, namely: (1) *Information Strategy Planning* as applied to the enterprise as a whole or to a subset of it in which an information architecture is built based on a high level function models and data models; (2) *Business Area Analysis* in which the enterprise's data models and process models are built for each business area identified in (1); (3) *Systems Design* that establishes a detailed logical and physical design of an application for a given business area; and (4) *Construction* in which the designed application is implemented and integrated with the other applications within and outside the business area. For the purpose of this study however, the first two levels namely Information Strategy Planning and Business Area Analysis have been applied and together formed the major tasks performed by the researcher for the purpose of modelling the strategic information for Universal as an enterprise. The first two stages were deemed to be adequate and appropriate to meet the objectives of this study as both stages are capable of representing and delivering a high-level information requirements of the enterprise.

The study took off when the Divisional Director who is the CEO of Universal agreed that the study be undertaken. The first task is to gain as much information about the company through the company's reports and brochures. Next, key personnel were identified representing major departments within the company. Information on each department's business functions, goals, critical success factors, problems and information needs were recorded and documented. On the basis of these information, first-cut enterprise conceptual models were developed. The models were high-level overview models and concerned with formalising Universal's goals, critical success factors and business functions. The models were described using the information engineering tools such as hierarchy of goals and functional decomposition.

Data and fact-findings were done through several phases of semi-structured interviews, first with the key personnel responsible for each department and then the main user who is also responsible for IT. Among the key personnel interviewed were the Sales and Marketing Manager, the Quality Assurance Manager, the Operations Manager, and the Administration Manager who is also responsible for IT. The Administration Manager is also the contact person for this study. A final interview was also done with the Divisional Director on the company's mission and general direction as well as to trash out any outstanding issues raised during the interviews with the key personnel. A total of seven interviews were held in a time-span of approximately 2 months each lasted between two to four hours.

Extracting the required information from the interviews in addition to the company's reports, forms and other documentation formed the first-cut conceptual model. The model was decomposed into two major models representing data and activity. The activity model was initiated by extracting the high-level functions from the conceptual model and further decomposed into a series of low-level functions. The result of the activity model is displayed using the function decomposition diagram.

Identification of subject areas acted as the starting point for developing the data model. Subject areas were identified by looking at the data requirements to perform those high-level functions defined in the conceptual model. In addition, subject areas can also be extracted by analysing the critical success factors. These subject areas are then decomposed into a series of entity types. Once the required entity types were identified, relationships between entities and their respective cardinalities can be defined. These can then be mapped to form an entity-relationship model (also known as ER Model). The ER Model can be used to represent the detailed information requirement of Universal.

The next step in the study was to produce recommended business areas that identified the required applications. This was done through two processes. The first process was to create an association matrix mapping entity types and functions according to their usage. Those entity types used by each function were checked. The output was the function-entity matrix. The second process was to perform an affinity analysis - an analysis based on entity clustering algorithm using the function-entity matrix as input. The algorithm proceeded by clustering those entities utilising the same functions to form an application group (business area) based on their affinity.

CHAPTER 2. ORGANISATIONAL ENVIRONMENT

2.1 Company's Profile

Universal Steel Tube Company (Universal) was established in 1930 as a manufacturing company for the cold drawn seamless steel tube industry. The company is located within the vicinity of the City of Birmingham 5 km from the city centre. Its primary business is in the production, manufacture, and supply of a range of tubing products for general engineering purposes and for a number of specialised markets which include the power and process industries, the automotive and transport industries and the heat transfer industry.

Universal is part of an American steel company, bought by Plymouth Tube based in Illinois, USA in 1988. However, its operation remains autonomous and Universal continues with its usual business making decisions without referring to the parent company. This however is limited to changes in corporate strategies and any major capital acquisitions that affect the way the company operates. Otherwise the company is its own entrepreneurship.

In 1994 Universal experienced major change in its strategy by moving into manufacturing of more specialised smaller diameter mechanical tubing, specifically for the automotive industry. This is part of its strategy to capture a market niche and add value to its products and services in order to better satisfy its customer's needs by becoming more focussed and specialised.

Today with an upgraded facility and a modern cold drawn operation, Universal is on the right track to become a profitable company producing carbon and low alloy steel tubing for the automotive, aircraft, construction, power generation and mining industries.

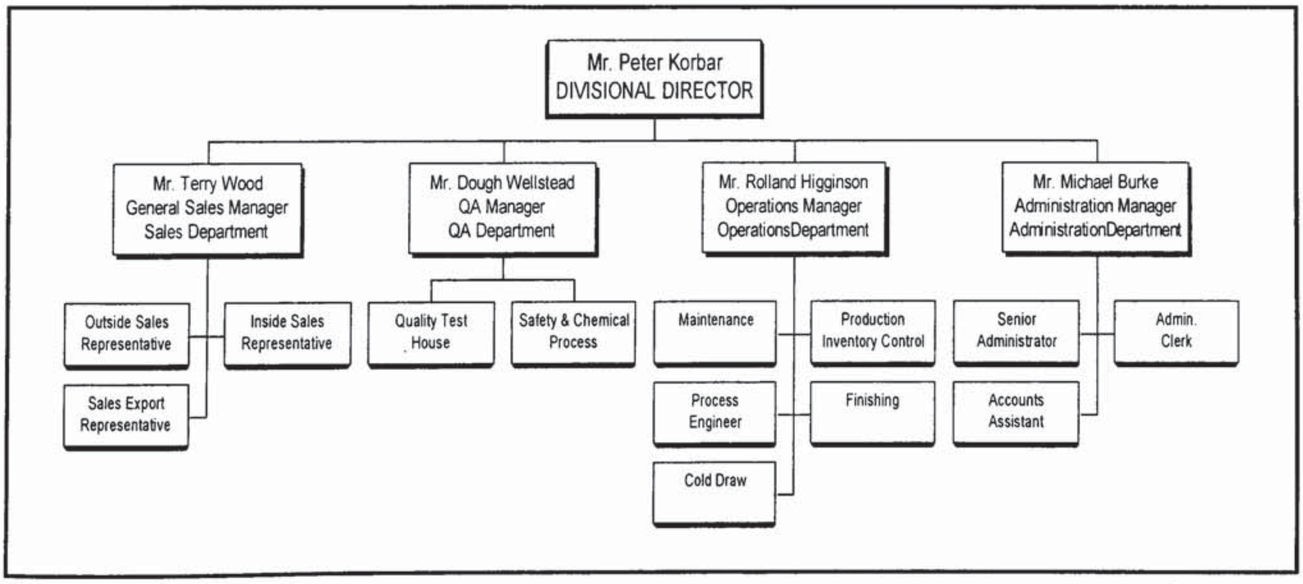
Universal employed 18 full-time staff, 11 in the site office and the remaining 7 in the shop floor within the same location. As part of its expansionary plan to increase productivity and to improve the quality of its products, the company is recruiting more people with the right skills and experience in order to move forward into the next millennium. The company has an annual sales turnover of approximately £4.5 million with sales mostly in the domestic market. With well proven, high quality products, the company aimed to increase its production by 20% and increase its export content by more than 10% of total production. Universal hoped to increase its sales forecasted for 1998 and to register moderate profit after broke-even in 1997. Universal is optimistic of achieving a steady growth rate of 20% per annum. This is made possible through its plans for expansion both within the management structure and its physical infrastructure, which includes its range of products and services, manufacturing facilities, technological innovation, and layout.

2.2 Organisation Structure

According to Universal's organisation chart up until the month of June 1998, Universal is lead by a Divisional Director who reports to the Executive Vice President of Plymouth Tube, USA.

Universal has a lean organisation structure. There are 4 departments supporting the divisional director each headed by senior and experienced managers. These departments are the Sales Department, the Quality Assurance Department, the Operations Department, and the Administration Department. Figure 1 below is the company's organisation chart with the rest of the operating units shown.

Figure 1. Organisation Chart of Universal Steel Tube Company Limited



2.3 Functional Areas of Departments

The **Sales Department** is responsible for the general sales of Universal's products and services. It is managed by a General Sales Manager who is responsible for both sales and marketing. Apart from generating sales leads and overlooking the overall sales activities of the company, the General Sales Manager is also involved in trade missions and advertisement to promote the company's products at home and abroad. The department is supported by 3 sales representatives, namely the Outside Sales, Inside Sales and Exports representatives. For the domestic market, the sales region is divided into 2. The Northern Region covers north of England and Scotland and is the responsibility of the Outside Sales representative who works from home. Inside Sales cover the Midlands and south whilst Exports deal with international sales.

The department is also emphasising sales over the automotive industries in line with the company's overall strategy to adopt a market focus and develop a niche by adding value to its products and services.

Another important department within Universal is the **Quality Assurance** (QA) Department. The department is headed by the QA Manager and supported by a Quality Test House Inspector and a Safety and Chemical Process Engineer. The department ensures that job specification of a certain job-in-progress as well as materials and finished products follow the company's own standards and comply with the industry standards as specified in the ISO 9001 documents. This is in line with the company's desire to maintain high quality standards for its products and in the process increasing product acceptance at the same time minimising or eliminating rejects and non-conformers. All materials and products are inspected for conformity and some will go through chemical treatment for further processing. The department also looks at customer complaints as part of the company's desire to maintain high standards of customer satisfaction.

The heart of Universal's manufacturing activities is the **Operations Department**. The shop floor houses the physical work areas where personnel and machines processed materials according to specified job schedules. The Operations Manager oversees the general management of the shop floor, planning the job schedule and allocating personnel and machine resources. He is assisted by supervisors in 5 units each performing production activities at a certain stage of the manufacturing process. The units are the Maintenance, Production Control, Process Engineering, Finishing, and Cold Draw. Each supervisors help ensure the smooth running of the daily production operation.

The **Administration Department** is the co-ordinating department between the Sales, the Operations and the QA departments. The Administration department is responsible for a wide range of activities which include personnel management, wages, training, finance, accounting, purchasing, invoicing, collection, sub-contracting and transportation. Headed by a diligent and experienced administration manager, the department is supported by 3 staff. These are the Senior Administrator, Administrative Clerk and Accounts Assistant. The department also maintains the IT use for the company.

CHAPTER 3. BUSINESS ENVIRONMENT

3.1 Universal's Strategic Plan

Part of the effort to acquire an IS strategy is to examine the company's strategic business plan. The *information engineering methodology* calls for the alignment of IS strategy with the company's business strategy so that any IS implementation will support the business in terms of its mission, goals and business functions. Hence Universal's strategic plan is a prerequisite for its IS strategy formulation, and the success of the research study depends on whether such a plan exists. In the absence of a documented plan as in the case of Universal, an alternative is to seek senior and top management's view of the current state of the business as well as their opinions regarding the future direction of the business. This is done by conducting semi-structured interviews to identify the company's mission, business functions, organisational units and their functional areas, strategic goals and objectives, and critical success factors and problems. The following sections describe Universal's business strategy based on interviews with top and senior management of the company.

3.1.1 Mission Statement

Universal has a formal mission statement that reads as follows:

We are committed to providing products and services that meet and exceed our customer expectations.

3.1.2 Strategic Goals

To support the above mission, a number of strategic goals have been identified. Some are taken from the mission statement and others through interview with the Divisional Director as part of what he see as strategic for the business. A summary of the strategic goals is list as follows:

- Produce and manufacture specialised smaller diameter tubing.

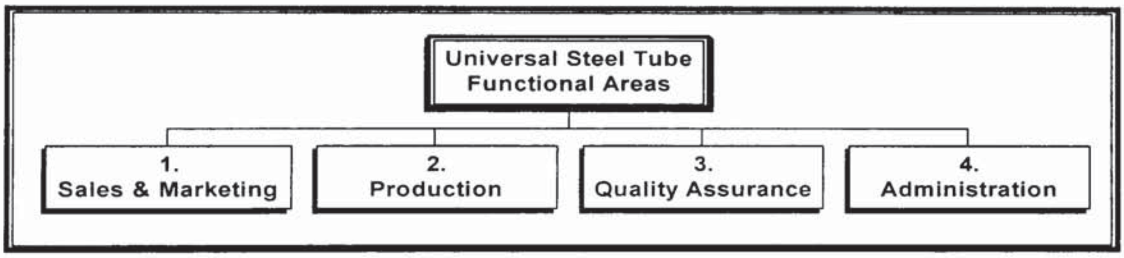
- Focus on the automotive industry
- Continue to look for market niche to do something different in order to survive and be competitive
- Continue to look at value added products and services to gain competition and customer satisfaction
- Commitment in people as part of the company
- People as responsible and committed to their work
- Identify and understand customer's expectation, both internal and external
- Develop long-term partnership with customers and suppliers
- Improve products, processes, services and systems
- Increase production by 20% per annum
- Increase export content by at least 10% of total production

3.2 Business Functions

From the perspective of the top management, Universal's business can be broadly categorised into 4 functions, which is in line with the major departments it has. These are the Sales and Marketing Function, the Production Function, the Quality Assurance Function, and the Administration Function.

Figure 2 below depicts the four high-level functions of the company.

Figure 2. Universal's Business Functions



The above figure also known as *Functional Decomposition Diagram* is used to sub-divide or decomposes each of the main function into several sub-functions. Each sub-function can further be decomposed into sufficient levels of detail to determine distinct business processes and activities. However, for the purpose of obtaining a high-level overview of the enterprise, decomposition will stop at the sub-function level or when the lowest-level function is reached.

A summary and breakdown of each of the main business function are described below using the sub-function decomposition diagram.

Figure 3. The Sales & Marketing Function

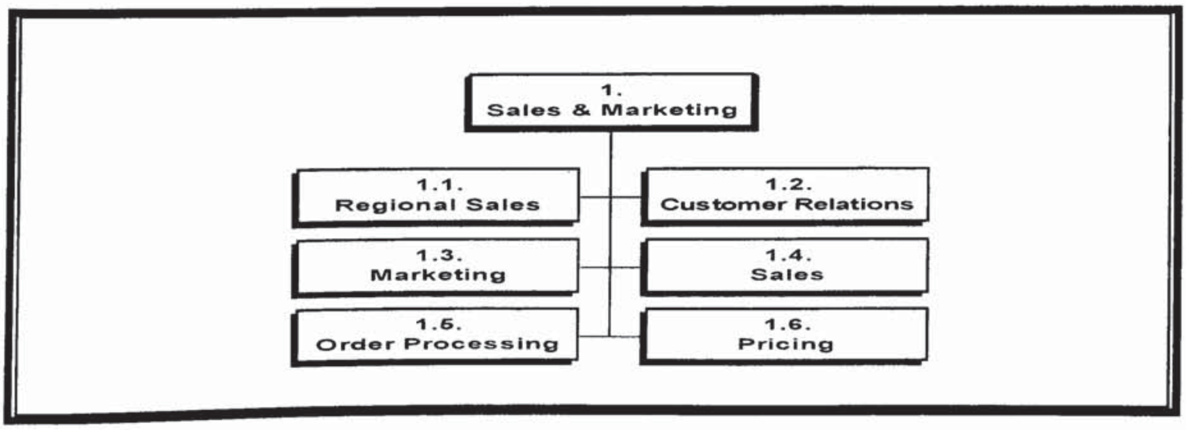


Figure 3 shows the sub-function for Sales and Marketing. Six sub-functions have been identified, namely Regional Sales, Customer Relations, Marketing, Sales, Order Processing and Pricing. Each sub-function is further decomposed into second-level sub-functions as shown in figures 3a to 3f below.

Figure 3a. Regional Sales Sub-Function

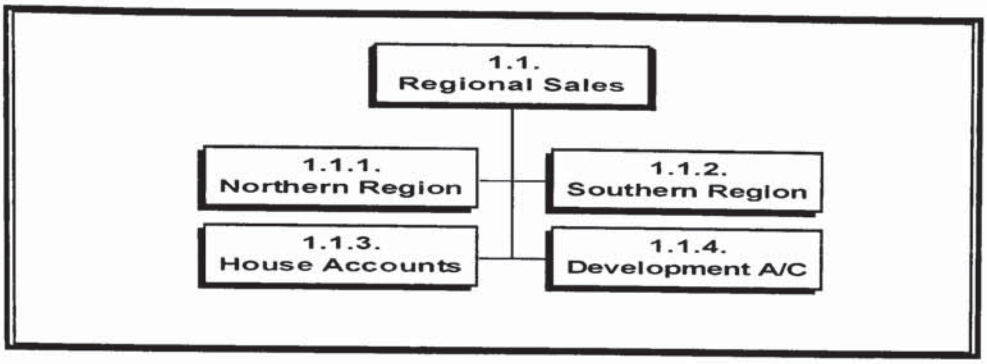


Figure 3b. Customer Relations Sub-Function

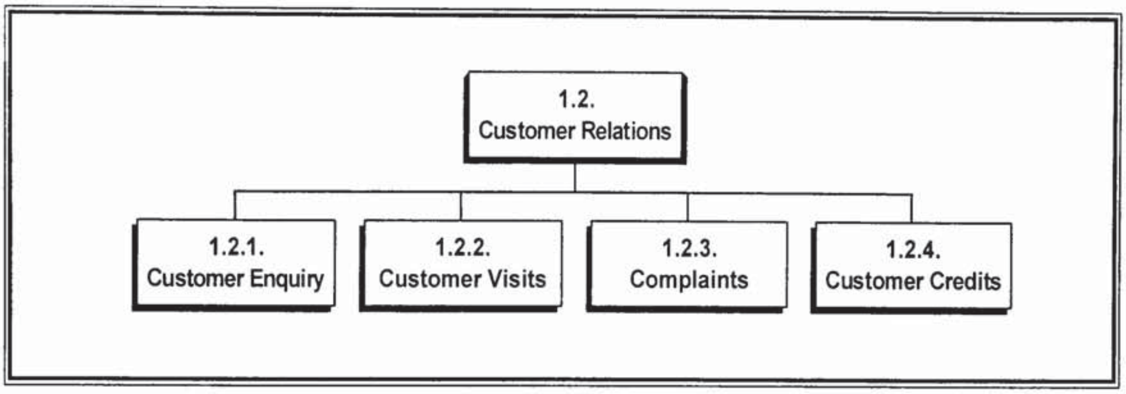


Figure 3c. Marketing Sub-Function

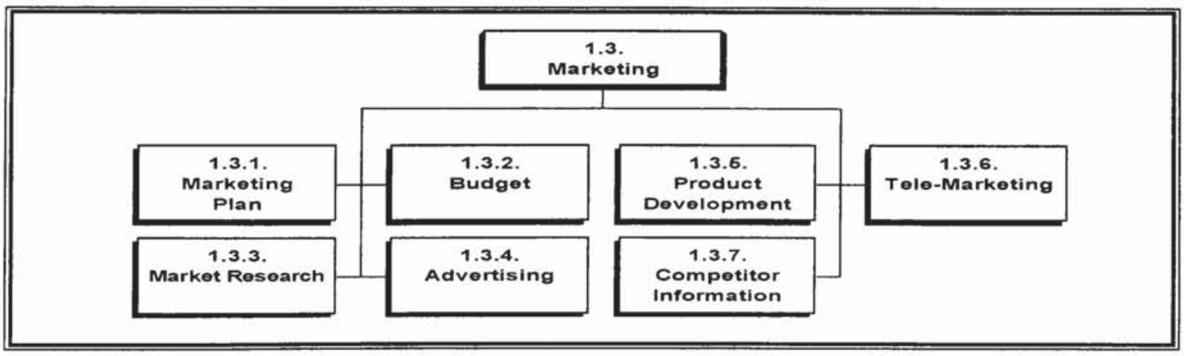


Figure 3d. Sales Sub-Function

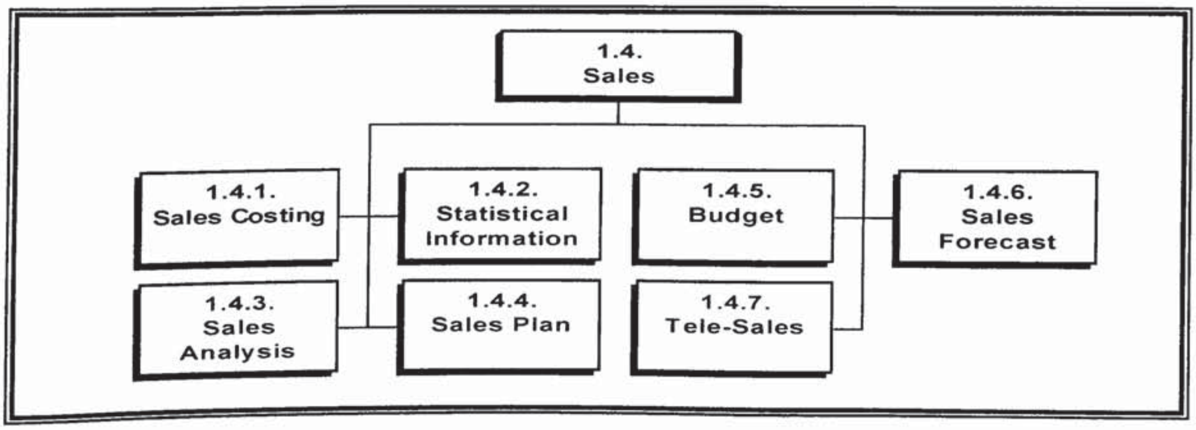


Figure 3e. Order Processing Sub-Function

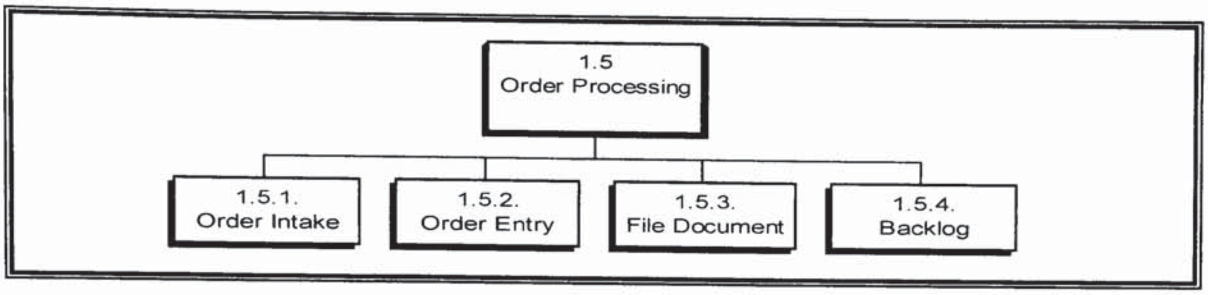


Figure 3f. Pricing Sub-Function

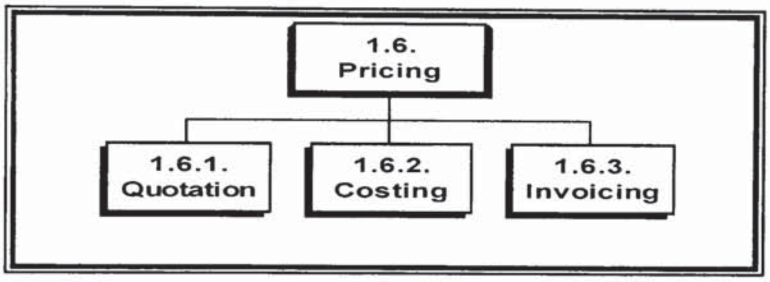


Figure 4 shows the sub-functions for Production. A total of 3 main sub-functions made up the production function. These are Production Planning, Production Operation and Maintenance. These sub-functions are decomposed into lower-level functions as described in Figures 4a through 4c below.

A typical production operation starts when the sales order generated by the Sales Function, and after going through the vetting procedures by the QA and the Administration functions, were passed to the Production Controller who performs the production planning. This includes costing of jobs and the number man-hours, scheduling of jobs and processes according to shifts, allocating raw materials and stock updates, and issuing production orders to the shop floor for the actual production operations.

Figure 4. The Production Function

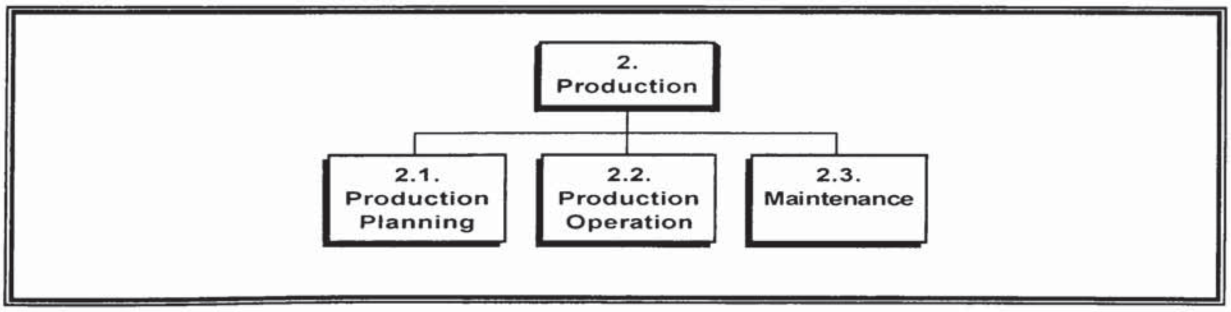


Figure 4a. Production Planning Sub-Function

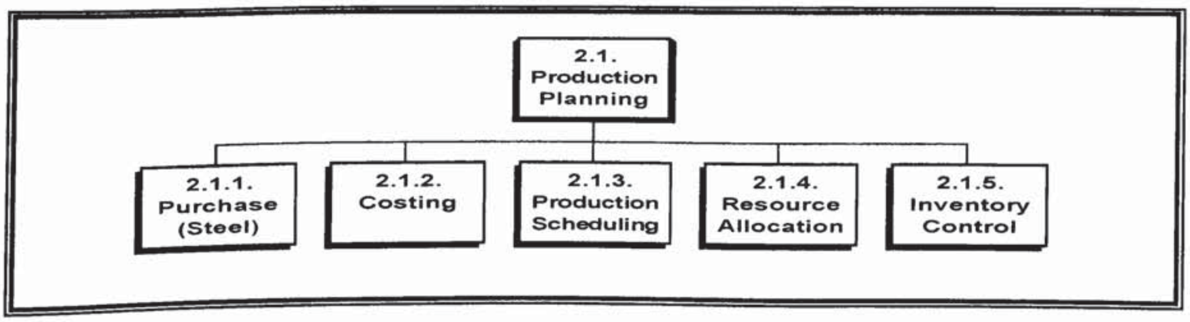


Figure 4b. Production Operation Sub-Function

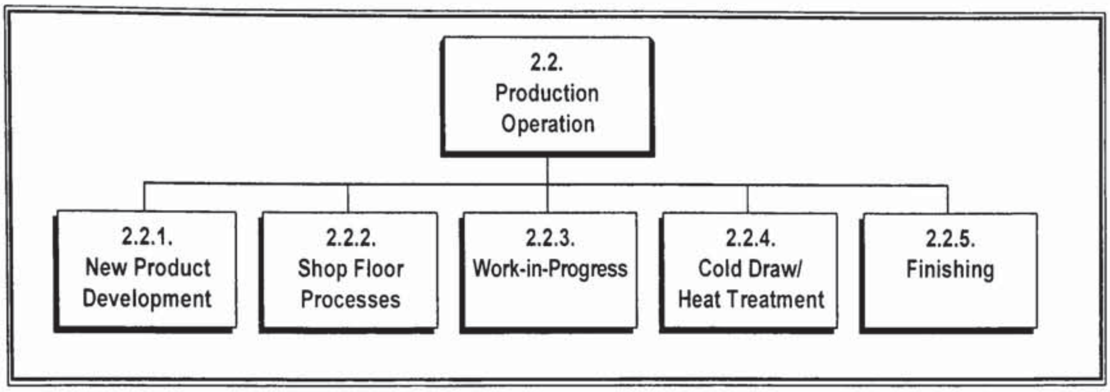
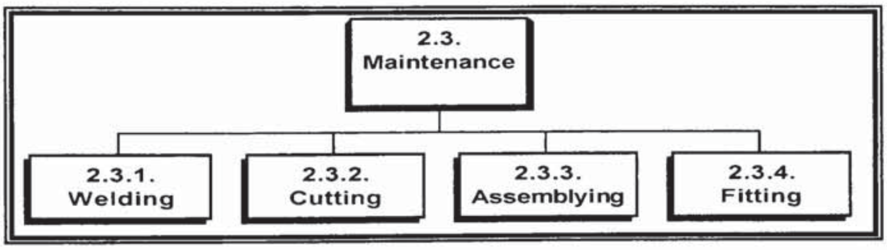


Figure 4c. Maintenance Sub-Function

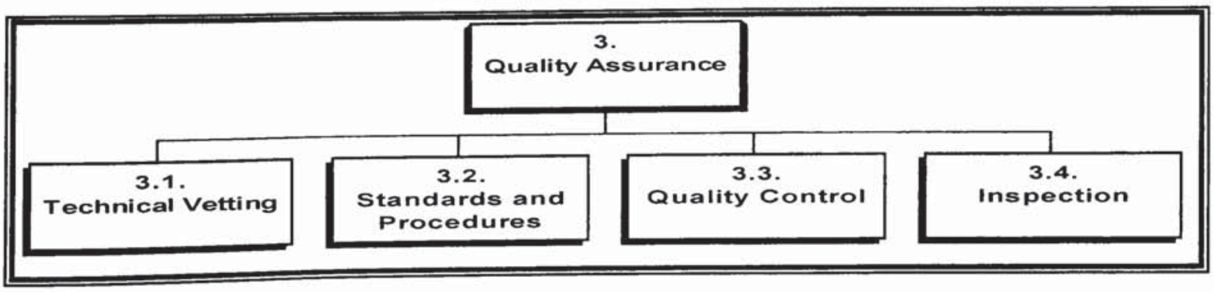


In the shop floor work-in-progress is recorded in a shift report, one for each operator, where a particular processes are active. The shift reports are collected to produce a master sheet showing all jobs at a particular week together with markings to show the status of a particular job.

Processes involve allocating pieces of raw materials and drawing (cold draw) them to sizes. When the tubes have been drawn and/or heat-treated (furnace) they will be passed to the Finishing function where they are cleansed and lubricated and if necessary, straightened. They are then tested for defects and then cut to the appropriate lengths and bundled together. Where necessary these tubes may be oiled before going to the warehouse ready for despatch to the customer.

Figure 5 depicts the sub-functions for the Quality Assurance function. There are 4 sub-functions namely, Technical Vetting, Standards and Procedures, Quality Control, and Inspection.

Figure 5. The Quality Assurance Function



Each sub-function is further decomposed into second-level sub-functions as shown in figures 5a to 5d below.

Figure 5a. Technical Vetting Sub-Function

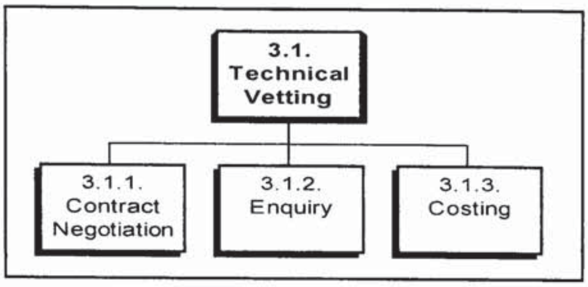


Figure 5b. Standards and Procedures Sub-Function

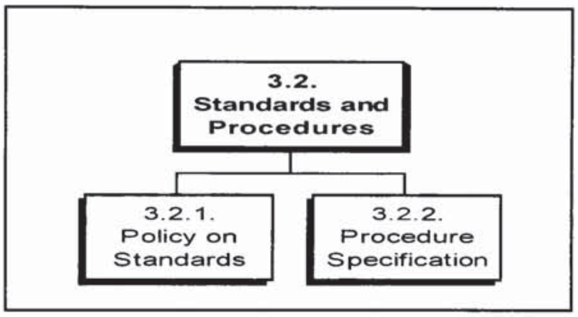


Figure 5c. Quality Control Sub-Function

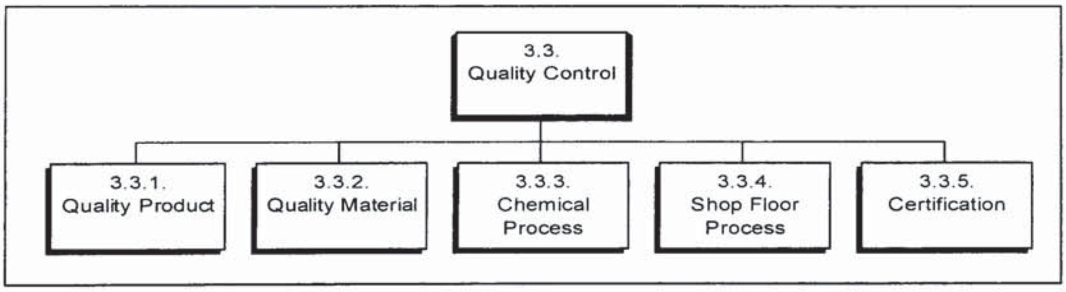
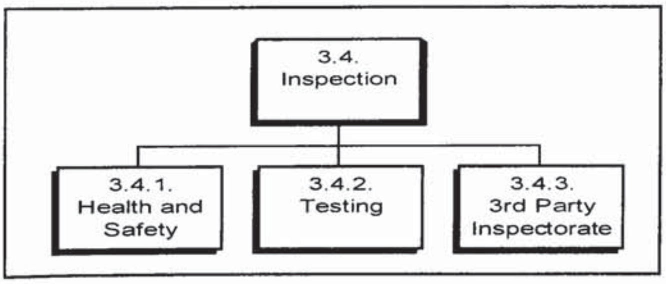
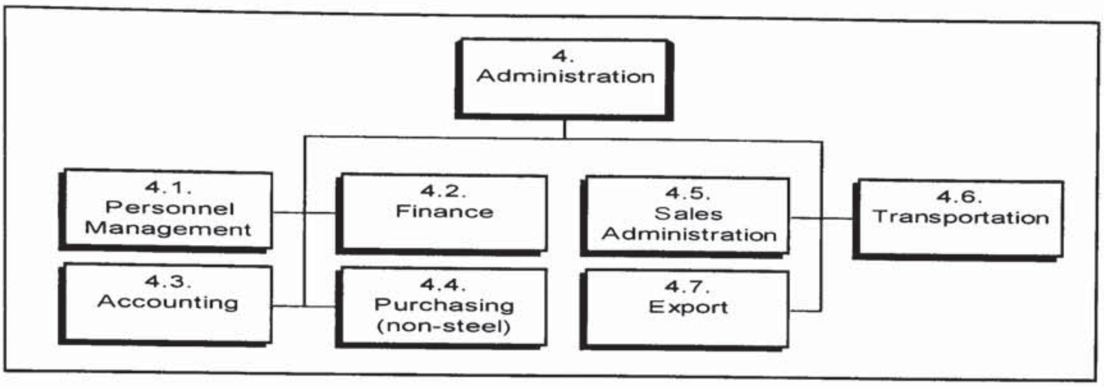


Figure 5d. Inspection Sub-Function



The Administration Function can be divided into 7 sub-functions. These are Personnel Management, Finance, Accounting, Purchasing (non-steel), Sales Administration, Transportation, and Export. Figure 6 below shows the sub-functions for the Administration Function.

Figure 6. The Administration Function



The above Administration sub-functions can be further decomposed into lower-level functions as shown in the following figures 6a through 6g.

Figure 6a. Personnel Management Sub-Function

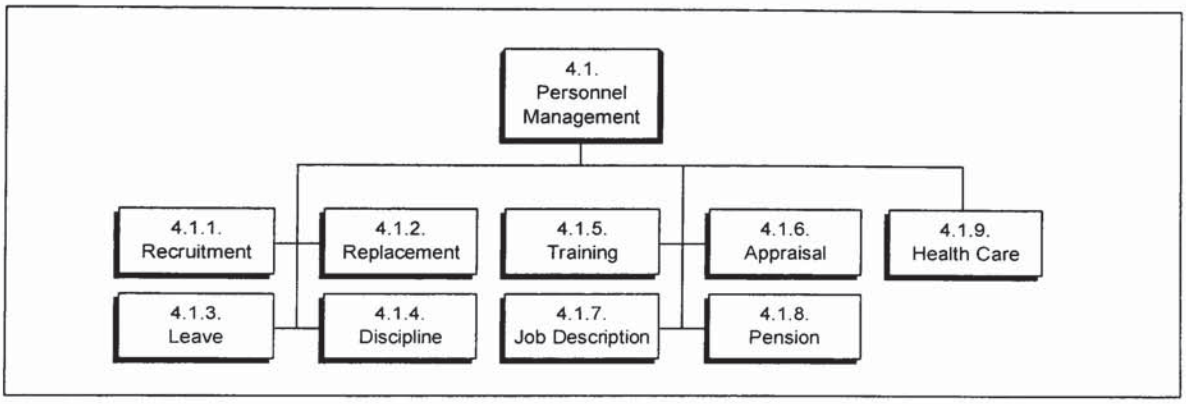


Figure 6b. Finance Sub-Function

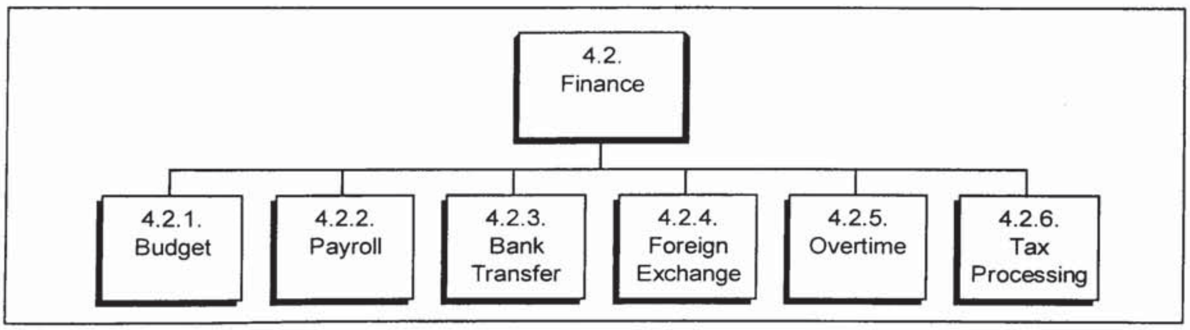


Figure 6c. Accounting Sub-Function

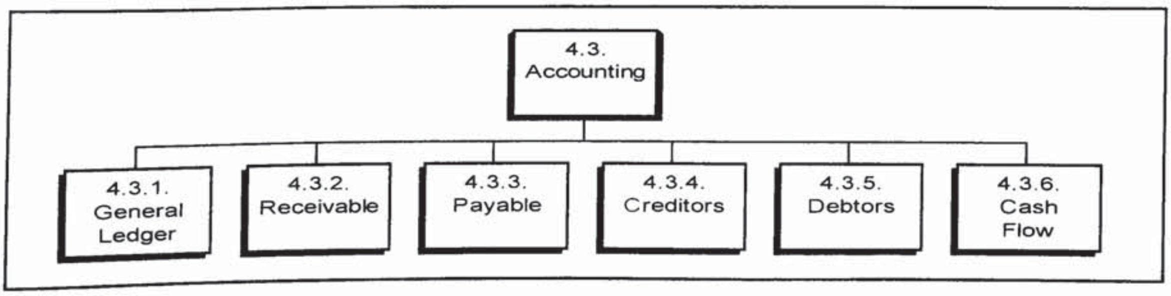


Figure 6d. Purchasing Sub-Function

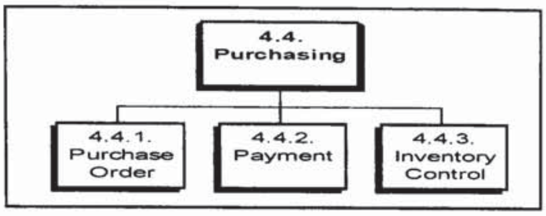


Figure 6e. Sales Administration Sub-Function

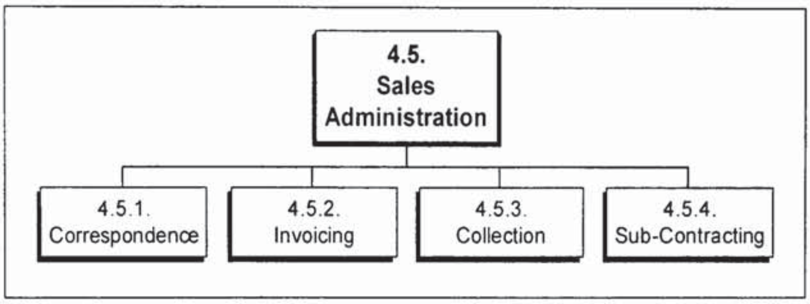


Figure 6f. Transportation Sub-Function

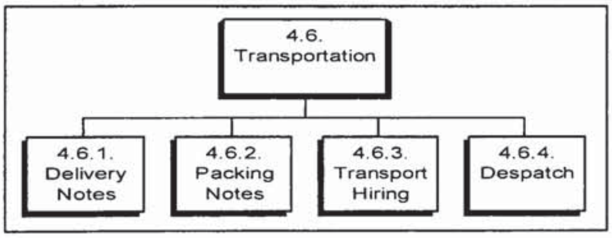


Figure 6g. Export Sub-Function

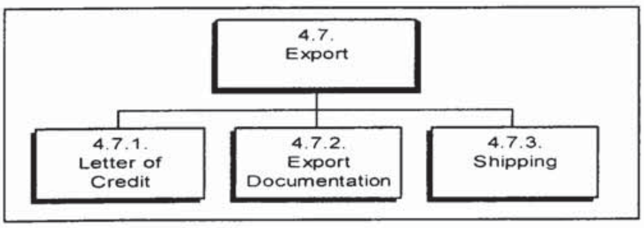


Table 1 below summarises the business objectives of the 4 main functions.

Table 1. Summary of Functional Objectives

Business Function	Functional Objectives
1. Sales & Marketing	• To achieve customer's satisfaction • React quickly to customer's demands • Retain customer base • Secure sales as forecasted • Meet or exceed sales forecast • Secure order backlogs which have sufficient volume and margin • Meet on time delivery of product to customer • Just-in-time delivery for stock of raw material and finished products

	• Increase in export content • Emphasis on scheduled demand order book as opposed to spot order • To have highly motivated people in the sales force • Employee development
2. Production	• Ensure on time delivery to customer • Ensure right quantity and quality of materials/resources are utilised • Pursue minimum cost in manufacturing by improving yields • Optimise use of labour • Ensure efficiency in supply of raw materials • Ensure products meet customer's requirements • Ensure stock is used efficiently by turning over stock every 2 months • Improve operations through new or improve production methods/equipment • Facilitate improvement in communication through out all levels of staff • Staff development and improvement for succession and flexibility • Identify training needs as part of skill development • Ensure operations conform to environmental requirements • Ensure operations adhere to health and safety guidelines and procedures
3. Quality Assurance	• Ensure no quality problems • Able to maintain rate of quality approval • Minimise customer complaints • Ensure tests and certification of raw materials are done on time
4. Administration	• Ensure purchases are at the best rate while maintaining quality • Able to produce performance figures within 2-3 days • Able to achieve account balances on time • Obtain better health care for employees • Ensure people are adequately trained • Ensure appropriate and proper IT implementation

3.3 Critical Success Factors and Critical Decisions

Critical Success Factors or CSF can be defined as those few key areas where things must go right for the business to flourish. These could be critical processes or business activities, or critical information that are required where failure in these areas could be disastrous to the business. The purpose of the CSF is to analyse the potential information needs of the respective business functions and to determine whether these needs are supported by the business goals and consistent with the functional objectives.

Table 2 summarises the CSF of the 4 main business functions identified in this study.

Table 2. Critical Success Factors

Business Function	Critical Success Factors
1. Sales & Marketing	• Timeliness - sales to production to dispatch • Access to customer's information • Availability of raw materials to produce products • New, current, potential and outstanding orders • Status of jobs-in-progress at a particular instance • Correct price levels • Correct volume and quantity produced • Sales order intake performance • Status of stock at any one time • Sales targets

	• Market statistics
2. Production	• Require high level of delivery on time (JIT) for supplies • Quality of raw materials is absolutely crucial • Require very competitive prices for raw materials in order to be competitive • Require flexible and adaptable work force for work processes • Employees sufficiently skilled, trained and right attitude towards tasks • Maintain quality of machines, procedures and tasks • Need a high degree of equipment availability • Information on major orders coming in • Backlog information (order book)
3. Quality Assurance	• Perform test tolerances on products conforming to specification • Perform accurate chemical process • Quality Management System • Conform to standards, procedures and practices
4. Administration	• Staff welfare • Payroll • Sales performance figures • Training • Quarterly budgets • Invoices • Customer orders • Up to date Store information • Backlog information • Leave records

Critical decisions are important business decisions that will support the CSF. A number of critical decisions have been identified for each business function and are listed in table 3 below. This will ultimately leads to the development of potential decision support systems as tools to aid in the decision making process.

Table 3. Critical Decisions

Business Function	**Critical Decisions**
1. Sales & Marketing	• Determine pricing levels • Determine limits on sales forecast • Determine workloads of sales staff • Decide on sales and marketing budgets • Decide on delivery time
2. Production	• Decide on purchase of materials • Decide on work in production schedule • Decide on work overtime • Allocate labour for optimal performance • Determine suitability of staff to carry out tasks • Determine resources to be allocated for tasks • Determine job priority (prioritising orders) • Determine work schedule • Decide on training requirements • Determine production budgets • Determine health and safety matters
3. Quality Assurance	• Decide on acceptance of raw materials • Determine product quality for acceptance

	• Decide on suitability of raw materials
4. Administration	• Hiring and firing • Decide on acceptance of purchase order • Determine sub-contract works • Decide on how to despatch goods • Determine mode of transport for delivery of finished products • Determine customer credits • Determine appropriate IT use

3.4 Analysis of Problems

Universal as with all other firms is not excluded from having problems. This tends to make it more difficult to achieve the required goals though usually solving a particular problem may actually be a step closer to achieving the goal. This study has recorded a number of problems based on interviews with the respective managers. The aim is to highlight some of these problems which may be critical and may have implications towards meeting the business as well as the operational objectives. During the course of the interviews, respondents have been very open and frank about the issues they faced. When attention is focussed on a particular problem, that problem is more likely to be solved. Furthermore by analysing these problems, certain information systems facilities may be of help as aids towards dealing with these problems.

Table 4 gives a list summary of problems quoted by the management of Universal. The analysis of the problems includes possible solutions, criticality of solving the problem, the business functions involved and the system or information requirements that deal with the problems.

Criticality is based on a ranking scale 1-5 as follows:

5 = Critical to operation of business and must be rigidly performed (such as mission-critical quality procedures).

4 = Critical to undisrupted operation of business (such as production schedule).

3 = Required to support business (eg. customer enquiry).

2 = Required to support business, however the importance and rigidity of the activity is lower than 3 (eg. regular scheduled reports).

1 = Desirable, but not absolutely required to support business.

3.5 Information Needs

Information needs are identified based on analysis of each functional area requirements and it's CSFs and problems. First-cut broad data subjects representing the highest level overview of Universal's information needs have been identified. This is represented in the form of a data subject decomposition diagram as shown in Figure 7.

The data subjects are then expanded to form entity types and a data model representing Universal's information needs can then be created in the form of an Entity Relationship Model. This model can later be used as the basis for developing the company's database.

The Data Subject Decomposition Diagram provides a complete overall description of the information needs for Universal. However, it needs to be transformed to a logical database schema for subsequent design. This would require the identification of the underlying attributes and identifiers that made up the entity in order to form the database structure.

Table 4. Problems Analysis

Problem	Solution	Criticality Rating	Inhibits Goals	Caused by Function	Impacts Function	Requires Entity/Systems
1. Lack of knowledge between varying and flexible order load and raw material on order or in stock would jeopardise on time production and delivery of finished products	• Accurate order loading • Accurate purchase order • Accurate stock of raw materials	4	• Secure order backlogs which have sufficient volume and margin • Meet on time delivery of product to customer • Just-in-time delivery for stock of raw material and finished products • Emphasis on scheduled demand order book as opposed to spot order • Ensure stock is used efficiently by turning over stock every 2 months	• Sales & Marketing • Production	• Sales & Marketing • Production	• Order Processing System • Inventory Control System
2. Lack of a good order processing system that would have impact on generating working document, manufacturing document, quality document, test certificate and invoicing	• Integrated Order Processing System • Integrated information systems	4	• Just-in-time delivery for stock of raw material and finished products • Ensure on time delivery to customer • Ensure efficiency in supply of raw materials • Ensure stock is used efficiently by turning over stock every 2 months		• Sales • Customer Relations • Production	• Sales Order Processing System • Purchase Order Processing System
3. Inquiry on stock of raw material too slow impact decision on order book	• Better stock information	3	• Just-in-time delivery for stock of raw material • Ensure efficiency in supply of raw materials • Ensure stock is used efficiently by turning over stock every 2 months	• Production	• Sales & Marketing • Production	• Inventory Control System • Sales & Purchase Order Processing Systems • SALES • PURCHASE

4. New, unfamiliar orders may require re-processing which may disrupt other jobs and planned processes	• Prioritise jobs and put on hold other jobs	3	• React quickly to customer's demands • Meet on time delivery of products to customer • Optimise use of labour	• Sales & Marketing • Production		• Job History
5. Getting rid of chemical affluence disrupt production operation	• Automatic treatment of water • Better management of production schedule	3	• Meet on time delivery of product to customer • Improve operations through new or improve production methods/equipment • Ensure operations conform to environmental requirements	• Quality Assurance	• Production	• Production Planning System
6. Defect materials realised in late stage inhibit on time delivery	• Possible replacement from stock • Keep track of supplier	3	• Meet on time delivery of product to customer • Ensure efficiency in supply of raw materials • Able to maintain rate of quality approval • Ensure tests and certification of raw materials are done on time	• Quality Assurance	• Production	• SUPPLIER • Inventory Control System
7. Poor quality design and printing of documents and test certificates affect company's image and customer satisfaction	• Better quality printing with colour laser printer • Source a graphics designer	2	• Achieve customer's satisfaction • Ensure appropriate and proper IT implementation	• Administration		
8. Rejecting normal orders due to limited production capacity affect company's image	• Increase production capacity • Employ more staff • Analysis of orders rejected	3	• Achieve customer's satisfaction • Retain customer base • Improve operations through new or improve production methods/equipment	• Production	• Sales and Marketing	• REJECTED ORDERS

			• Minimise customer complaints			
9. Too much paperwork and cross-referencing of documents consume time	• Increase computerisation • Integrated Information Systems	3	• React quickly to customer's demands • Facilitate improvement in communication throughout all levels of staff • Ensure appropriate and proper IT implementation	•	• Administration	• TRAINING
10. Lack of information on status of orders inhibits efficient Order Processing	• Better system for Order Processing	4	• React quickly to customer's demands • Secure sales as forecasted • Meet or exceed sales forecast • Meet on time delivery of product to customer • Ensure purchases are at the best rate while maintaining quality	• Sales & Marketing • Production • Administration		• ORDERS • WORK-IN-PROGRESS • SALES FORECASTS • Sales Order Processing System
11. Key staff went on long leave inhibit smooth running of the business	• Better staff placement system • Employ more staff	3	• Optimise use of labour • Staff development and improvement for succession and flexibility		• Production • Quality Assurance	• Human Resource Information System
12. Lack of training among staff affects job performance	• Better training system	4	• To have highly motivated people • Employee development • Optimise use of labour • Staff development and improvement for succession and flexibility • Identify training needs as part of skill development • Ensure people are adequately trained	• Administration	• Administration • Quality Assurance • Production	• EMPLOYEE • TRAINING • Personnel System

13. Lack of computerised systems to speed things up	• Plan for IT • Implement more computerised applications	3	• Improve operations through new or improve production methods/equipment • Facilitate improvement in communication throughout all levels of staff • Able to produce performance figures quickly • Able to achieve account balances on time • Ensure appropriate and proper IT implementation	• Administration	• Administration • Sales and Marketing • Production • Quality Assurance	• Integrated Information Systems
14. Lack of integration among computerised systems leads to duplication of data entry and information	• Integrated Information Systems • Proper plan for IS strategy	3	• Improve operations through new or improve production methods/equipment • Facilitate improvement in communication throughout all levels of staff • Ensure appropriate and proper IT implementation	• Administration	• Administration • Sales and Marketing • Production • Quality Assurance	• Integrated Information Systems
15. High rate of staff turnover	• Better staff motivation • Better human resource management	4	• To have highly motivated people • Employee development • Optimise use of labour • Staff development and improvement for succession and flexibility		• Administration • Sales and Marketing • Production • Quality Assurance	• Human Resource Information System

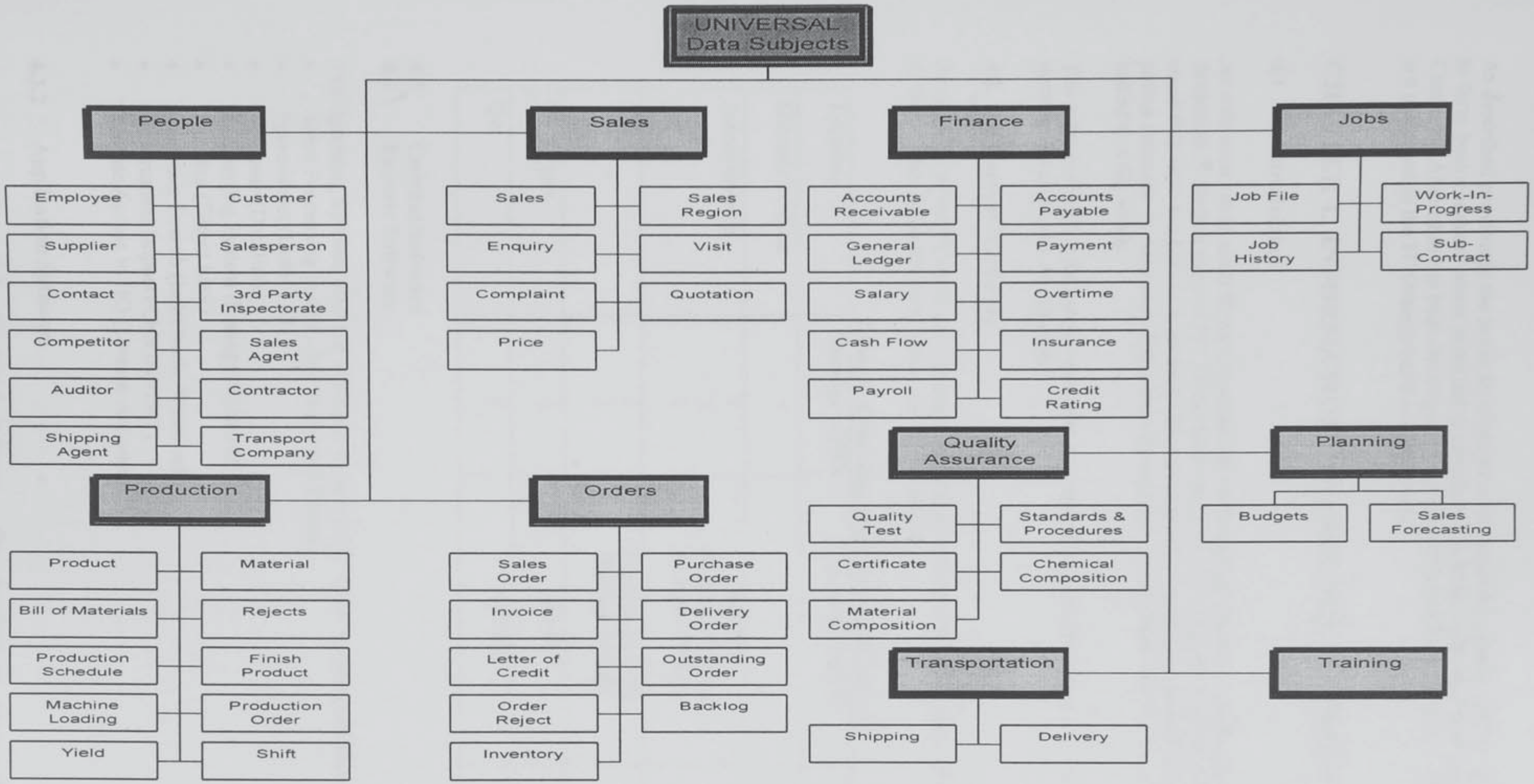


Figure 7. Data Subjects Decomposition Diagram

As described previously the lower level business functions are used to cluster the entity types together to form business areas where potential applications can be developed. For this purpose an Entity Clustering Algorithm has been developed to implement the Affinity Analysis. Results of this analysis are presented in the IT Strategy section of this report.

CHAPTER 4. INFORMATION TECHNOLOGY ENVIRONMENT

4.1 Introduction

As with most other small firms, Universal has no formal information systems structure and no dedicated IT staff to support IT. IT has been use since 1983 with the first PC installation. By 1992 more PCs were bought and a network link was established to transfer accounts information to the parent company in America. There are currently 8 PCs connected within a Local Area Network and linked to a file server.

The Administration Manager assumes the responsibility for the company's IT and carries out the systems development work himself.

4.2 Current Hardware

Acquisition of the PCs was done in stages according to the needs at the time. The PCs are distributed to the various departments as shown in Table 5 below.

Table 5. Computer Hardware and Printers

Location	Number of PCs	Type of Computer	Number of Printers
Director's Office	-		
Administration	1 2 1	486 DX Pentium 133Mhz Pentium 200Mhz	4
Sales	1 1	Pentium 133Mhz Pentium 166Mhz	1
Production	1	486 DX	1
QA	1	486 DX	1

4.3 Current Software

4.3.1 Systems Software

The Operating Systems used are Windows 95 and DOS. Other systems software include:

- Word Processing System (MS-Word and Textra)
- Spreadsheet (Lotus 123)
- Database (DataEase)
- Accounting System (Prestige Multisoft)
- Banking (Direct Link)
- Customer Search (InfoCheck, WinCheck)
- Government Import (CN8 INSTAT)
- Remote Access to HQ (Lawson Accounts)

4.3.2 Application Software

Applications are mainly developed in-house. The development tools used to develop these applications are DataEase, a relational database management system and Lotus 123 spreadsheet. A list of the applications is shown in Table 6 below.

Table 6. List of Application Software

Application	**Usage** (currently using,upgrading,developing)	**Source** (package,in-house,3rd party)
Accounting Systems	Currently using	Package
Planning	Currently using	In-house
Personnel and Training	Currently using	In-house
Sales Order Intake	Currently using	In-house
Invoice and Despatch	Currently using	In-house
Work-In-Progress	Currently using	In-house
Test Certificates	Currently using	In-house
Product Analysis	Currently using	In-house
Budgets	Currently using	In-house

Currently Universal is evaluating a number of additional applications in the Sales, Production and Administration functions. These include Quotation, Order Processing, Production Planning, Despatch and Invoicing applications.

4.4 Information Systems Organisation

As mentioned earlier Universal has no formal IS organisation. However, the Administration Manager assumes the overall responsibility for IT adoption as well as making decisions on purchases and determines policies and procedures for the use of IT across the company. Overall, members of the management are very receptive to IT and all managers have access to PCs. Studies have shown that top management support is important for IS success particularly in small firms. A positive attitude towards IT is also critical for increased sophistication in the use of IT. Universal has the right characteristics for IT success as evidenced by the majority of the managers interviewed having positive attitudes toward IT.

With the absence of professional IT staff, users are resorting to end-user computing in a controlled manner. Few key staff is authorised to develop applications using Spreadsheet to maintain their current work. Company-wide applications are developed by the Administration Manager who has formal training in application development. Other users may develop queries to retrieve information from existing databases to facilitate individual work without compromising on data integrity and duplications.

CHAPTER 5. INFORMATION TECHNOLOGY STRATEGY

5.1 Information Systems Strategy

Universal's business mission and strategies highlight the importance of the people, the product and the process aspects of the business. Foremost within the people aspect is the customer, an external entity that keeps the company in business. Equally critical is the internal entity, employee that ensure the company is operating effectively and most importantly meeting the needs of the customer.

To ensure the effectiveness of Universal's information systems plan, the company's strategic information has to be closely aligned to its strategic business objectives. The implementation of this information system strategy has to take into account the company's business strategy so that the priority of developing information system applications will be based on the company's business strategies. Based on the analysis that has been done, a number of information systems applications have been identified that would satisfy these needs. These applications are formed as a result of performing *Affinity Analysis* associating Universal's business functions with its information needs. Appendix I shows the association matrix mapping business functions with information needs (entities). A "C" in each cell indicates a function that creates the corresponding entity (ie. source of information), and a tick mark (3) denotes the function uses the corresponding entity as "read-only" access (ie. no capability of creating, updating or deleting). It is assumed that a function that creates an entity can also update and delete that entity.

The associated matrix in Appendix I constituted the input for the Entity Clustering Algorithm which is a major procedure within the Affinity Analysis. A computer program was written in Ada to implement the Affinity Analysis. The matrix defined the relationship between the 70 functions and the 62 entities. A relationship between a function and an entity exists if the function uses the entity in its execution. The algorithm will compute Affinity Factors, which represent the proportion of the number of Functions using a pair of entities out of the number of Functions using one element of the pair. Entities with high affinity factors with a given entity will be grouped together to form an entity cluster. This is repeated for all combinations of entities. Affinity analysis is also performed on a set of defined parameters. In order to ensure consistency in the analysis, a combination of thresholds were fitted into the program and a trend is identified. This simulation revealed that there were entities that always belong to a cluster, while other entities moved among the clusters with different thresholds. The aim is to identify the best patterns that fit these entities. Results of the affinity analysis are included in appendix 2.

The analysis yields 17 clusters utilising all 62 entities. These clusters are then examined for similarity in their characteristics to form into groups representing potential business areas. Table 7 below shows the summary of the potential business area classification based on the analysis. Ten business areas have been identified with each revealing their own distinct characteristics as a result of the cluster groupings.

Table 7. Business Area Classification for Universal Steel Tube Company Ltd.

Business Area	Entity Type	Cluster
1. Delivery	Delivery Delivery Notes Destination Carrier Shipping Agents Packing Notes Transport Company Letter of Credit	1 2
2. Production	Job History Machine Load Work-in-Progress Production Schedule Job File Production Order Material Shift	3
3. Customer Information	Visit Complaint Enquiry Sales Region Finished Product Credit Rating Customer Receivable Certificate Site	4 8
4. Financial	Supplier Purchase Order Payable Payment Cash Flow Overtime General Ledger Salary Financial Budget	5 6 7

	Cost Price	
5. Quality Assurance	Reject Product 3rd Party Inspectorate Standards & Procedures Quality Test Chemical Composition Material Composition	9 16
6. Personnel	Skill Department Employee Training	10
7. Contract	Contractor Sub-contract	11
8. Order Processing	Order Reject Outstanding Order Order Backlog Invoice Sales Order	13 15
9. Sales	Quotation Product Sales Person Commission Sales Competitor	12 14
10. Inventory Control	Bill of Material Inventory	17

Each business area identified consists of entities that are closely related that would result in the formation of several applications accessing the same data sources. For each business area an application portfolio is formed to analyse the information strategy by dividing the applications into one of 4 priority areas. These are (1) *Strategic*; (2) *Operational*; (3) *Potential*; and (4) *Support*. *Strategic* applications are those that are critical to the future success of the business. Applications that are closely related to supporting the company's mission and business goals should belong to this category. Applications in the *Operational* category are those that are critical in supporting the day-to-day business activities. Their development should be given top priority. Whereas *Potential* applications are those that will move to the *Strategic* category depending on availability of technology and resources. Applications that belong to the *Support* category are those that can facilitate and improve the management and activities of the business area.

A description of each proposed business area and its underlying application portfolios is presented next.

a) Delivery
Five applications are identified within this business area. A Delivery system would be helpful to track the delivery and distribution of the finished products to customer sites. Information regarding the transportation and shipping companies should also be included. The other applications are printing of Invoice, Delivery Order and Packing Notes, which can be generated based on information processed within the Order Processing business area. A fifth application, an Electronic Data Interchange (EDI) would be helpful to facilitate export documents and Customs. This application should be considered when Universal has the necessary support resources particularly in the telecommunication area as the majority of the problems encountered in the implementation of EDI involve telecommunication and network. Table 7a summarised the application portfolio within the Delivery business area.

Table 7a. Application Portfolio for the Delivery Business Area

STRATEGIC	POTENTIAL
	• Electronic Data Interchange
OPERATIONAL	**SUPPORT**
• Invoice • Delivery Order • Packing Notes	• Delivery System

b) Production

The Production business area includes those applications supporting the production operations. A Job Booking application should be developed to book jobs and create job files which would then be accessed by the Production Scheduling system for resource planning and scheduling. The application is categorised as *Operational* as it could facilitate the management of production resources which is crucial for effective production scheduling and operations.

Other applications include a Production Scheduling System, a Work-in-Progress application, a Capacity Planning application, and a Work Shift System. These applications are not only critical to the production business area but also to other business areas and should be considered mission-critical. As such they should be categorised as *Operational* and their development should be given priority. However, a quick alternative to this is to acquire a Material Requirements Planning (MRP) system whose components include the 3 applications mentioned above and inputs from the Inventory system, Bill of Materials, and the Order Processing System developed within the Inventory and Order Processing business areas. If this option is chosen, the MRP system should be categorised as *Strategic* as opposed to *Potential* due to its importance and criticality to the business.

Table 7b shows the application portfolio for the Production business area. Other supporting applications may include details of tasks performed on specific jobs for archive purposes, and a database application to maintain information on products and components that require re-works and/or were rejected for quality reasons.

Table 7b. Application Portfolio for the Production Business Area

STRATEGIC	POTENTIAL
• MRP System	
OPERATIONAL	**SUPPORT**
• Job Booking • Production Scheduling System • Work-in-Progress Application • Capacity Planning Application • Work Shift System	• Tasks Archive • Re-work and Reject Database Application

c) Customer Information

Table 7c shows the application portfolio for the Customer Information business area. The development of a Customer Database could be considered strategic, as customer information is critical and central to Universal. Other applications may access the customer database as read-only and any updates or maintenance on customer information should be done using the Customer Database application.

Table 7c. Application Portfolio for Customer Information Business Area

STRATEGIC	POTENTIAL
• Customer Database	
OPERATIONAL	**SUPPORT**
• Enquiry System • Credit Rating Application	• Ad-hoc queries • Appointment System

The *Operational* category includes an Enquiry System that is a front-end application supporting customer and potential customer queries and a Credit Rating application to monitor customer's credit worthiness. The Enquiry system should be built on several modules each grouped into common subject based on past query experience. Other applications such as Ad-hoc queries and an Appointment System are categorised as *Support* as they could help to increase the efficiency of the Customer Information business area. To cater for the development of the Ad-hoc queries, a simple and systematic training in end-user computing should be given to all users. This training should focus on developing simple query to access the customer database and other information. The aim is to release some of the burden of the development team by letting users to develop their own queries to satisfy their information needs.

d) Financial
The Financial business area would include the typical finance and accounting applications where a range of standard packages is available off the shelf. Financial management involves planning, managing, controlling, co-ordinating, implementing and using financial allocation and resources adequately to support the business activities. A Financial Information System would be the strategy to support the financial business area, which includes budgets, allocation, expenditures, accounting, receivables and payables, loans, collection, payroll, cash flows and other financial information. These applications are categorised as *Support* since financial information though very important to the business, but they do not contribute directly to the mission and goals of the business.

Figure 7d shows the application portfolio for the Financial Business Area.

Table 7d. Application Portfolio for the Financial Business Area

STRATEGIC	POTENTIAL
OPERATIONAL	**SUPPORT** • Budgets • Payroll • General Ledger • Account Receivable • Account Payable • Purchasing • Payment • Supplier Database • Collections • Tax

e) Quality Assurance
A number of applications have been identified to support the Quality Assurance business area. The application portfolio to analyse each application strategy is shown in Table 7e below.

Table 7e. Application Portfolio for Quality Assurance Business Area

STRATEGIC	POTENTIAL
• Quality System	
OPERATIONAL	**SUPPORT**
• Audit System	• Certificate Prints • Rejected Products Database • Chemical & Material Composition

Quality System has been identified as a business strategy for Universal and is closely related to the company's mission and strategic goals. Quality System includes quality standards and procedures, and quality tests. It is therefore important that the development of a Quality Information System application be planned and developed.

The *Operational* category consists of an Audit application, which is an important application that ensures the quality of all Universal's activities are maintained. The *Support* category includes a Print Certificate application, a Rejected Products Database and a Chemical and Material Composition application.

f) Personnel

Staff welfare has been identified to be strategic to Universal. As the company expands, more staff would be recruited and an effective management of human resource would be much needed. An integrated Human Resource Information Systems should cater for the needs of human resource planning, staffing, staff development, skills, rewards and compensation, performance and appraisals, legal, health and safety, and employee assistance. Obviously a formal Information Systems structure would be needed to support and maintain such systems. Table 7f categorised the Human Resource Information Systems under the *Potential* category.

Based on existing requirement, 3 personnel applications are identified in the *Support* category. A personnel database application should be developed to maintain personnel records, which can also be accessed by other applications such as payroll and production scheduling. Staff Training and Skill Inventory should also be developed as part of supporting the personnel management. These applications should later be upgraded and their data migrated to the Human Resource Information Systems.

Table 7f. Application Portfolio for the Personnel Business Area.

STRATEGIC	POTENTIAL • Human Resource Information System
OPERATIONAL	**SUPPORT** • Personnel Database Application • Staff Training • Skill Inventory

g) Contract

Table 7g shows the application portfolio for the Contract business area. Two applications have been identified to support this business area.

Table 7g. Application Portfolio for the Contract Business Area

STRATEGIC	POTENTIAL
OPERATIONAL	**SUPPORT** • Contractor Database • Sub-Contract Application

Developing a Contractor database would be beneficial to facilitate referencing and cross-referencing multitude of contractors for sub-contract works. A Sub-Contract application should also be considered to manage and monitor sub-contract activities.

h) Order Processing

This business area has also been identified as strategic to Universal's business. Efficient and effective order processing directly impacts the company's mission and goals. As described previously, an Order Intake application is up and running. This system should be incorporated in a more comprehensive integrated Sales Order Processing and Purchase Order Processing Systems and link to other applications such as the Inventory Control System, Bill of Materials, Customer Information System, Supplier Database, Sales and Purchasing applications.

The application portfolio for the Order Processing business area is shown in Table 7h below.

Table 7h. Application Portfolio for Order Processing Business Area

STRATEGIC	POTENTIAL
• Sales Order Processing System • Purchase Order Processing System	
OPERATIONAL	**SUPPORT**
	• Order Information System • Supplier Database Application • Rejected Orders

Three other applications included in the *Support* category are the Order Information System to monitor outstanding orders and keep track of rejected orders, and a Supplier Database Application. Apart from information regarding suppliers, a rating system may also be incorporated to identify "good" suppliers according to combinations of quality, delivery, price, service, etc.

i) Sales

Nine applications have been identified to support the Sales business area. A model can be developed and implemented in an electronic spreadsheet for sales forecasting. Past sales data can be used as input to the model and different values can be fitted to examine sales trends and generate "what-ifs" scenarios. This can later be extended to form a Sales Decision Support System that links to other databases to analyse the necessary data and information as an aid for making sales decisions. For example the Sales DSS can be used to generate alternative scenarios if a new sales is accepted showing the implications to materials and other resources, its impact on the existing jobs, production schedules and operations, and the company's profitability. The Sales Forecasting application is categorised as *Strategic* whilst the Sales DSS could be *Potential* as shown in table 7i.

Table 7i. Application Portfolio for the Sales Business Area

STRATEGIC	POTENTIAL
• Sales Forecasting	• Sales Decision Support System
OPERATIONAL	**SUPPORT**
• Pricing Application • Quotation printing • Account Maintenance Application	• Complaints Application • Commission System • Competitor Information • Product Database

Applications in the *Operational* category include Pricing application, printing of Quotation, and an Account Maintenance application. This latter application can be used to maintain and monitor sales activities for a given account under the responsibility of a salesperson.

Applications contain in the *Support* category includes recording and analysis of complaints, Commission system, maintaining Competitor information, and a Product Database. The Complaints application should include cross-analysis of different types of complaints, complaint ratings, frequency of occurrence, sources, and actions taken. With the Internet facility links could be created to establish a network with the parent company and other associated companies where information could be disseminated electronically world-wide in a matter of seconds. Internet linkages to other firm's home pages could also be established for information on competitors.

A Product database application should be used to create information on new products and to maintain existing product information in order to facilitate sales.

j) Inventory

This business area is formed to provide an information strategy for effective management and control of equipment and materials to ensure a smooth and efficient production operation. An integrated Inventory Control system and the Bill of Materials application should be developed to support the business strategy of providing Just-in-Time delivery and optimal utilisation of materials and resources. These applications are critical to the operation of the business and their development should be given priority. As such they are placed within the *Operational* category as in Table 7j. Links should also be provided to integrate with the Order Processing system, the Supplier database application, and the Delivery system to form a complete Distribution System. External links to selected suppliers should also be considered for automatic re-ordering and replenishment of stocks and materials.

Table 7j. Application Portfolio for the Inventory Business Area

STRATEGIC	POTENTIAL
	• Interface Triggers to Suppliers
OPERATIONAL	**SUPPORT**
• Inventory Control • Bill of Materials	

5.2 **Information Systems Organisation Strategy**

As more opportunities are now available for businesses to adopt IT, IT has inadvertently become a change agent to influence the way the business operates. However, the benefits derived from the technology can only be achieved through proper planning and placement of the appropriate IT infrastructure. Otherwise the adoption of IT will become a new burden for the organisation resulting in high costs of investment and inappropriate use of IT human resources.

The information system strategy documented in this report is aimed at addressing this in order to meet Universal's information requirements that are becoming more complex. Relying on an informal IS function is no longer appropriate and practical for a company that is expanding its IT investment. Currently all departments within Universal have computers with access facility to a network file server. With the development of more applications and acquisition of packages, a formal and organised IT administration is appropriate and should be considered with the main aim of providing a company-wide co-ordination and compatibility of hardware and software. In addition, this will also help ensure the effectiveness of future implementation of Universal information systems.

A unit called **Information Systems Office** (ISO) should be established and placed under the responsibility of the Administration Department. This is consistent with the department's own business strategy to promote the use of IT company-wide. Furthermore the Administration Department has the tradition in IT and it is only appropriate to formalise the IS structure here. However most IS literature suggests that an IS organisation should be located at the highest level possible to reflect the importance of IT to the whole organisation, and more importantly to ward off any influence a particular department or division has over IT policy and implementation.

The strategy for the ISO organisation includes identifying specific functions to support Universal's IS implementation, the roles and responsibilities of the functions, and IT human resource requirements. It is suggested that an IT Steering Committee be formed comprising senior members of the management acting as an advisory body that determines IT policies and IS implementation strategies. This committee should be chaired by the Divisional Director himself and the ISO manager as its secretariat.

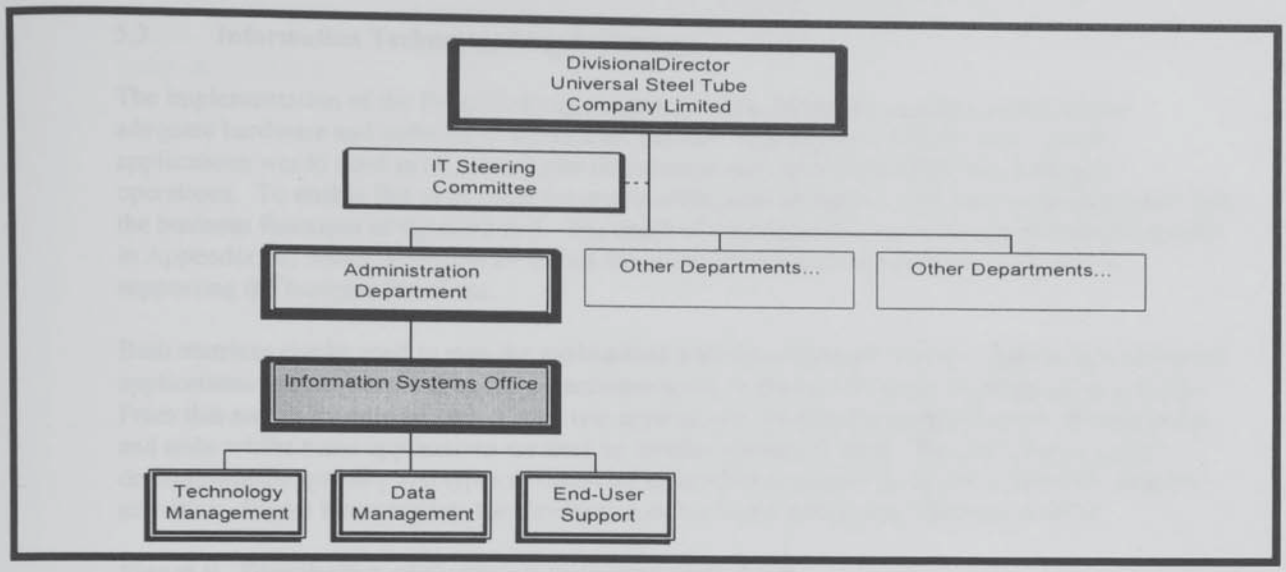
Organisation Structure of the ISO

The Information Systems Office will be headed by a manager responsible for IT planning, developing IS strategy, and implementing Universal's information systems in accordance with the directions as laid out by the IT Steering Committee. This should represent user requirements endorsed by the top-level management. Basically, 3 main functions have been identified to support this responsibility. These are:

1. Technology management
2. Data Management
3. End-user support

The organisation structure of the ISO is shown in Figure 8 below.

Figure 8. Organisation Structure of the Information Systems Office



The aims of the Technology Management function are to develop and manage Universal's IT infrastructure. Among its responsibilities include:

- Oversee the installation and operation of the company's computer equipment.
- Provide technical support for installation of systems software and packages.
- Oversee the installation and operation of telecommunication network and cabling requirements.
- Prepare a technology plan to organise, monitor and implement IT standards and policies based on guidelines by the IT Steering Committee.
- Develop software applications using a standard programming language and other fourth generation language application development tools.

This function should be supported by personnel with a technical background trained in IT preferably in computer science, electronic engineering and/or communication network.

The Data Management function manages data and information produced by the applications for managing the company's information system. Its responsibilities include:

- Provide support for IS projects involving the development and implementation of databases and database application development.
- Create, develop and maintain database structures and data dictionary as a centralise repository of data resources.
- Perform daily database management systems (DBMS) operations that include determining control procedures, security, access rights, fallback, and backup and recovery.
- Assist in systems analysis and other programming tasks in application development. May also assist in end-user development under the co-ordination of the End-User Support function.

This function should be supported by a Database Administrator or an analyst who has a working knowledge in database design and administration.

End-User Support provides support services to all users as part of the company's effort to promote the use of IT. Basically, this function is responsible for:

- As a link between the users and ISO to address problems associated with the use of IT facilities. This include providing *help-desk* services to co-ordinate problems and *trouble-shooting* activities including liaison with vendors.
- Assist in the preparation of MIS reports and other printing materials to the management and end-users. This may also be extended to Universal's agents and clients.
- Provide consultation and advisory services to end-users in connection with the administration and monitoring of end-user computing policies and procedures.
- Organise IT training programmes for staff.

The Manager ISO himself, or an IT Administrator with a good understanding of the business and with some interest in IT should be the candidate to support this function.

5.3 Information Technology Supply Strategy

The implementation of the IS applications suggested in the IS Strategy section would require adequate hardware and software to support the business requirements of Universal. These applications would need to be accessed by departments and units responsible for their daily operations. To enable this to be done the organisation units of figure 1 will need to be associated with the business functions of figures 2 to 5. The result of these associations is a usage matrix as depicted in Appendix III, whilst Appendix IV shows the association matrix representing applications supporting the business functions.

Both matrices can be used to map the applications with the organisation units. Appendix V shows the applications that are accessed by the organisation units as derived from the mapping of the matrices. From this matrix it could be seen that certain applications are used by a large number of departments and units whilst some applications are used by smaller number of units. This forms the basis of determining the quantity and types of hardware and software needed to support Universal's business activities. Figure 9 summarises the distribution of hardware among the organisation units.

Figure 9. Distribution of Hardware to Organisation Units

Hardware

Organisation Units	File Server	Printer Server	PC Client	Local Printer
MD's Office			1	1
Administration Department	1	1	4	2
Sales Department	1	1	2	1
Operations Department		1	3	1
QA Department			1	1
Totals	2	3	11	6

As shown in Figure 9, two file servers are required to store the databases and the shared applications. One of the file servers should be a mirror image of the other and should be placed in different locations for security and disaster recovery purposes. To facilitate sharing of printing resources, three printer servers should be linked to the network and possibly segmented to cover certain departments for optimal use and minimised network congestion. A total of 11 PCs are required to support user access to the applications. This is an increase of 3 additional PCs from the present 8, to cater for the application development and IS management tasks as a result of forming the Information Systems Office.

Figure 8 also shows the minimum hardware requirements needed to support the initial development and implementation of the applications suggested earlier. As more systems are put in place and application usage increases bigger capacity and high performance servers would be required. In addition, as the company expands and more people are employed, more PCs will need to be acquired to support the number of users.

The high degree of IT resource sharing across the departments implies that there is a high sharing of applications and data among the departments. With the distributed computing resources, part of the IT Supply strategy is to create an integrated communication network system. The existing network system within Universal may be enhanced to cover all the departments to facilitate sharing of the computing resources.

APPENDIX 6: Lists of Systems and IT products, Technology and Applications

Systems List and IT Plan

1. CAD/CAM
2. Electronic Mail
3. Internet
4. Decision Support Systems/ Executive Information Systems
5. Computer Integrated Manufacturing
6. Mail Merge
7. Electronic Data Interchange
8. Point-of-Sales
9. Desk Top Publishing
10. Numerically Controlled Machines
11. Database
12. MRP
13. Graphics
14. Robotics
15. Expert Systems
16. Word Processing System

Technology List

1. Facsimile
2. Mobile Phone
3. Telephone
4. PABX
5. Modem
6. Electronic Personal Organiser
7. Video/Tele Conference
8. Network Hub, Router, Bridge, Gateway
9. ISDN

Application List

1. Accounting/Finance
2. Contracts
3. Credit Control
4. Customer Service
5. Distribution/Dealership
6. Engineering
7. Fixed Asset Management
8. Forecasting
9. Inventory Control
10. Invoice/Billing
11. Marketing/Advertising
12. Material Control
13. Personnel Management
14. Project Management
15. Purchasing
16. Sales
17. Production Operation
18. Supplies

APPENDIX 7: CASE STUDY ACTIVITY SCHEDULE

Case Study Activity Schedule (March - December 1998)

				March					April				May				June		
Activity	**Resource**	2/3	9/3	16/3	23/3	30/3	6/4	13/4	20/4	27/4	4/5	11/5	18/5	25/5	1/6	8/6	15/6	22/6	29/6
Case Study Preparation																			
Kick-off Meeting																			
Britannia Heat Transfer Ltd.	MD,GM																		
Universal Steel Tube Co.	MD,Adm																		
Interviews: Data Collection																			
Sales & Marketing functions	GM, Britannia																		
Contracts functional area	Mgr, Britannia																		
Sales & Marketing functions	GM, Universal																		
Production function	Mgr, Universal																		
Quality & Safety functions	Mgr, Universal																		
Administration function	Mgr, Universal																		
Sales & Marketing functions	GM, Britannia																		
Quality Assurance	Mgr, Britannia																		
Production function	Mgr, Britannia																		
IS function	GM, Britannia																		
Company's strategy	MD, Britannia																		
Administration function	Mgr, Universal																		
IS function	Mgr, Universal																		
Company's strategy	MD, Universal																		
End-user Profile	GM, Britannia																		
End-user Profile	Mgr, Universal																		
Data Transcription																			
Review Interview Text	Interviewees																		
Develop Enterprise Information Model																			
Conduct Business Area Analysis																			
Review Data & Process Model	Universal																		
Review Data & Process Model	Britannia																		
Prepare IT Research Reports																			

Case Study Activity Schedule (March - December 1998)

				July			August						September			October			
Activity	**Resource**	6/7	13/7	20/7	27/7	3/8	10/8	17/8	24/8	31/8	7/9	14/9	21/9	28/9	5/10	12/10	19/10	26/10	
Case Study Preparation																			
Kick-off Meeting																			
Britannia Heat Transfer Ltd.	MD,GM																		
Universal Steel Tube Co.	MD,Adm																		
Interviews: Data Collection																			
Sales & Marketing functions	GM, Britannia																		
Contracts functional area	Mgr, Britannia																		
Sales & Marketing functions	GM, Universal																		
Production function	Mgr, Universal																		
Quality & Safety functions	Mgr, Universal																		
Administration function	Mgr, Universal																		
Sales & Marketing functions	GM, Britannia																		
Quality Assurance	Mgr, Britannia																		
Production function	Mgr, Britannia																		
IS function	GM, Britannia																		
Company's strategy	MD, Britannia																		
Administration function	Mgr, Universal																		
IS function	Mgr, Universal																		
Company's strategy	MD, Universal																		
End-user Profile	GM, Britannia																		
End-user Profile	Mgr, Universal																		
Data Transcription																			
Review Interview Text	Interviewees																		
Develop Enterprise Information Model																			
Conduct Business Area Analysis																			
Review Data & Process Model	Universal																		
Review Data & Process Model	Britannia																		
Prepare IT Research Reports																			

Case Study Activity Schedule (March - December 1998)

Activity	Resource	November 2/11	9/11	16/11	23/11	30/11	December 7/12	14/12	21/12
Case Study Preparation									
Kick-off Meeting									
Britannia Heat Transfer Ltd.	MD,GM								
Universal Steel Tube Co.	MD,Adm								
Interviews: Data Collection									
Sales & Marketing functions	GM, Britannia								
Contracts functional area	Mgr, Britannia								
Sales & Marketing functions	GM, Universal								
Production function	Mgr, Universal								
Quality & Safety functions	Mgr, Universal								
Administration function	Mgr, Universal								
Sales & Marketing functions	GM, Britannia								
Quality Assurance	Mgr, Britannia								
Production function	Mgr, Britannia								
IS function	GM, Britannia								
Company's strategy	MD, Britannia								
Administration function	Mgr, Universal								
IS function	Mgr, Universal								
Company's strategy	MD, Universal								
End-user Profile	GM, Britannia								
End-user Profile	Mgr, Universal								
Data Transcription									
Review Interview Text	Interviewees								
Develop Enterprise Information Model									
Conduct Business Area Analysis									
Review Data & Process Model	Universal								
Review Data & Process Model	Britannia								
Prepare IT Research Reports									

APPENDIX 8: INTERVIEW APPOINTMENTS FOR THE CASE STUDY INVESTIGATION

Date	Time	Destination/Purpose
25/03/98	1000 hrs	Aston University - Britannia Heat Transfer Limited, Station Rd., Coleshill Kick-off meeting with Mr. David Pierce (MD) and Mr. Gerrard Pierce* (GM) Company briefing, tour of plant and introduced to key staff.
31/03/98	1030 hrs	Aston University - Universal Steel Tube Company Limited, Bertha Rd., Birmingham Kick-off meeting with Mr. Peter Korbar (MD) and Mr. Michael Burke* (Adm. Manager). Tour of plant, Company briefing, and introduced to key staff.
06/04/98	0900 hrs	Aston University - Britannia Heat Transfer Limited, Station Rd., Coleshill Interview and data collection. Interview with Mr. Andrew Parker (Sales Director). Interview with Mr. Peter Chadwick (Contracts Manager).
09/04/98	1000 hrs	Aston University - Universal Steel Tube Company Limited, Bertha Rd., Birmingham Interview and Data Collection. Interview with Mr. Terry Wood (GM Sales) Interview with Mr. Rolland Higginson (Production Manager)
17/04/98	1000 hrs	Aston University - Universal Steel Tube Company Limited, Bertha Rd., Birmingham Interview and Data Collection. Interview with Mr. Doug Wellstead (QA Manager) Interview with Mike Burke (Adm. Manager)
24/04/98	0900 hrs.	Aston University - Britannia Heat Transfer Limited, Station Rd., Coleshill Interview and Data Collection. Interview with Mr. Andrew Parker (Sales Director) ...cont./ Interview with Mr. Mathew Warne (QA Manager) Interview with Mr. Gerrard Pierce (GM - Development)
05/05/98	0900 hrs.	Aston University - Britannia Heat Transfer Limited, Station Rd., Coleshill Interview and Data Collection. Interview with Mr. Gerrard Pierce (GM - Production)
13/05/98	1030 hrs.	Aston University - Universal Steel Tube Company Limited, Bertha Rd., Birmingham Interview and Data Collection. Interview with Mr. Peter Korbar (MD) Interview with Mr. Mike Burke (Adm. Manager) ...cont./
14/05/98	0900 hrs.	Aston University - Britannia Heat Transfer Limited, Station Rd., Coleshill Interview and Data Collection. Interview with Mr. David Pierce (MD) Interview with Mr. Gerrard Pierce (IT Inventory)
20/05/98	1000 hrs.	Aston University - Universal Steel Tube Company Limited, Bertha Rd., Birmingham Interview and Data Collection. Interview with Mr. Mike Burke (IT Inventory)
08/06/98	0930 hrs.	Aston University - Universal Steel Tube Company Limited, Bertha Rd.,

		Birmingham Interview and Data Collection. Interview with Mr. Peter Korbar (MD). ...cont./
15/06/98	0900 hrs.	Aston University - Britannia Heat Transfer Limited, Station Rd., Coleshill Interview and Data Collection. Interview with Mr. Gerrard Pierce (EUC)
23/06/98	1000 hrs.	Aston University - Universal Steel Tube Company Limited, Bertha Rd., Birmingham Interview and Data Collection. Interview with Mr. Mike Burke (EUC)
19/10/98	1030 hrs.	Aston University - Universal Steel Tube Company Limited, Bertha Rd., Birmingham Review Business Functions, data and process models Discussions with Mr. Peter Korbar and Mr. Mike Burke
05/11/98	0900 hrs.	Aston University - Britannia Heat Transfer Limited, Station Rd., Coleshill Review Business Functions, data and process models Discussions with Mr. Gerrard Pierce
10/11/98	1030 hrs.	Aston University - Universal Steel Tube Company Limited, Bertha Rd., Birmingham Review Business Functions, data and process models Discussions with Mr. Peter Korbar and Mr. Mike Burke
27/11/98	0930 hrs.	Aston University - Britannia Heat Transfer Limited, Station Rd., Coleshill Review Business Functions, data and process models Discussions with Mr. Peter Korbar and Mr. Mike Burke

*Contact person
Distance from Aston University to Britannia Heat Transfer Limited, Station Rd., Coleshill is 48km.
Distance from Aston University to Universal Steel Tube Company Limited, Bertha Rd., Birmingham is 4km.

APPENDIX 9: SOURCE PROGRAM FOR ENTITY CLUSTERING ALGORITHM

```
WITH CS_Int_Io;    USE CS_Int_Io;
WITH CS_Flt_Io;    USE CS_Flt_Io;
WITH CS_File_Io;   USE CS_File_Io;
WITH Ada.Text_Io; USE Ada.Text_Io;

PROCEDURE Affinity_Analysis IS

--*****************************************************************
--This program performs Affinity Analysis for entity clustering.  It
--takes 3 inputs, (1) list of functions from Function.dat; (2) list
--of Entity from Entity.dat; and (3) a matrix associating functions
--with entities in Matrix.dat.  The affinity algorithm will
--calculate affinity factors for all pairs of entities in the entity
--list.  For each pair it will calculate the percentage of the
--number of time the pair together being accessed by some functions
--out of the number of time one of the entity pair being accessed
--alone.  The aim is to group entities that are accessed by common
--functions together into clusters so as to form potential business
--area applications.
--
--This program is to help facilitate a case study research conducted
--on 2 small firms to analyse their information strategies
--ultimately to contribute to viable strategy for End-User Computing
--in small firms.
--
--Reference: Information Engineering Volume 2 by James Martin,
--Savant Institute (1986)
--
--Author : Zulkhairi Dahalin
--Program: PhD. (Information Systems)
--Dept.  : Division of Electronic Engineering & Computer Science
--         Aston University
--         Birmingham B4 7ET
--         United Kingdom
--Date   : 15 November 1998
--*****************************************************************
--Identifier and variable declaration

  MaxNameLen   : CONSTANT Natural := 30; -- length of entity/
                                         -- function name
  MaxRow       : CONSTANT Natural := 70; -- maximum row in matrix
                                         -- (function)
  MaxCol       : CONSTANT Natural := 62; -- maximum column in matrix
                                         -- (entity)
  MaxCluster   : CONSTANT Natural := 60; -- maximum clusters
                                         -- possible
  MaxClusterElement : CONSTANT Natural := 60; --max entities in a
                                         -- cluster
  Blank        : CONSTANT Character := ' '; -- blank character for
                                         -- spaces

  SUBTYPE NameString IS String(1..MaxNameLen+1);
--Declare a 2-D array to hold values of the association matrix
  TYPE Matrix2D IS ARRAY (Positive RANGE <>, Positive RANGE <>) OF
Character;
--Declare an array to hold names of functions and entities
  TYPE FunctionEntityArray IS ARRAY (Positive RANGE <>) OF
NameString;
```

```
--Declare a 2-D array to hold factor analysis result
  TYPE SquareMatrix IS ARRAY (Positive RANGE <>, Positive RANGE <>)
OF Float;
--Declare an array of record arrays of type integer to hold result
--of entity clustering
  TYPE ClusterArray IS ARRAY (1..MaxClusterElement) OF Integer;
  TYPE ClusterRecord IS RECORD
    ClusterElement  : ClusterArray;
    LastElement     : Integer;
  END RECORD;
  TYPE ClusterType IS ARRAY (1..MaxCluster) OF ClusterRecord;
--Declare an array of records to hold the ordered list of affinity
--factors for clustering (sorted in descending order)
  TYPE PriorityList IS RECORD
    EntityRow       : Integer; --the entity no. for the row of
                               --EntityMatrix
    EntityCol       : Integer; --the entity no. for the column of
                               --EntityMatrix
    AffinityFactor  : Float;   --affinity factor value of cell in
                               --EntityMatrix
    AffinityFactorR : Float;   --the reverse factor to determine
                               --closeness of pair
  END RECORD;
--The array of records containing the no. of cells in EntityMatrix
--minus its diagonal
  TYPE OrderedListArray IS ARRAY (1..MaxCol**2-MaxCol) OF
PriorityList;

  TYPE EntityIncArray IS ARRAY (1..MaxCol) OF Character;

  SUBTYPE MatrixData IS Matrix2D (1..MaxRow, 1..MaxCol);

  SUBTYPE FactorMatrix IS SquareMatrix (1..MaxCol, 1..MaxCol);

--Declare a slice of matrix data temporarily to find number of
--functions using entity pair (identifier declared in sub-module
--FunctionsUsingMatrix)
  SUBTYPE FunctionUsingMatrix IS Matrix2D (1..MaxRow, 1..2);

--*****************************************************************
  FUNCTION UpperCase (Ch : Character) RETURN Character IS
--To convert lower case letter to upper case.
    Shift : CONSTANT Integer := Character'Pos('A') -
                                Character'Pos('a');
  BEGIN
    IF Ch >= 'a' AND Ch <= 'z' THEN
      RETURN Character'Val(Shift + Character'Pos(Ch));
    ELSE
      RETURN Ch;
    END IF;
  END UpperCase;

--*****************************************************************
  PROCEDURE Options (NewC, Symm, AddC, UseC   : OUT Float;
                     Print_AM, Print_ON, Print_C : OUT Boolean) IS
--Sub-module to provide the user-interface to input threshold values
--for the clustering algorithm and some printing options.
    AM, ON, C  : Character;
  BEGIN
    New_Page;
    Put(Item => "AFFINITY ANALYSIS");
    New_Line;
```

```
    Put(Item => "================");
    New_Line(2);
    Put(Item => "Enter the following threshold values (1 - 100
         %):");
    New_Line(2);
    Put(Item => "   i.  Minimum New Cluster Affinity     = ");
    Get(Item => NewC);
    New_Line;
    Put(Item => "   i.  Minimum Symmetric Affinity       = ");
    Get(Item => Symm);
    New_Line;
    Put(Item => "  ii.  Minimum Add To Cluster Affinity  = ");
    Get(Item => AddC);
    New_Line;
    Put(Item => " iii.  Minimum Usable Affinity          = ");
    Get(Item => UseC);
    New_Line(3);
    Put(Item => "Print Options:");
    New_Line(2);
    Put(Item => "   i.  Print Affinity Matrix? (Y/N)     = ");
    Get(Item => AM);
    New_Line;
    Put(Item => "  ii.  Print Object Names? (Y/N)        = ");
    Get(Item => ON);
    New_Line;
    Put(Item => " iii.  Print Clusters? (Y/N)            = ");
    Get(Item => C);
    New_Line;
    NewC   := NewC/100.0;
    Symm   := Symm/100.0;
    AddC   := AddC/100.0;
    UseC   := UseC/100.0;
    IF UpperCase(AM) = 'Y' THEN
      Print_AM := True;
    ELSE
      Print_AM := False;
    END IF;
    IF UpperCase(ON) = 'Y' THEN
      Print_ON := True;
    ELSE
      Print_ON := False;
    END IF;
    IF UpperCase(C) = 'Y' THEN
      Print_C := True;
    ELSE
      Print_C := False;
    END IF;
  END Options;

--*******************************************************************
  PROCEDURE InputObject (ObjectArray : IN OUT FunctionEntityArray;
                         Count       : OUT Integer) IS
    ObjectLength : Natural;
--Sub-module to input function/entity names
  BEGIN
    Count := 0;
    WHILE NOT End_Of_File LOOP
      Count := Count + 1;
      Get_Line(Item => ObjectArray(Count), Last => ObjectLength);
      IF ObjectLength = 0 THEN
         Count := Count - 1;
      END IF;
```

```
    END LOOP;
  END InputObject;
--*****************************************************************
  PROCEDURE InputMatrix (MatrixArray         : IN OUT MatrixData;
                         RowCount, ColCount : IN Integer) IS
--Sub-module to input association matrix (function vs entity)
  BEGIN
    FOR I IN 1..RowCount LOOP
      FOR J IN 1..ColCount LOOP
        Get(Item => MatrixArray(I,J));
      END LOOP;
    END LOOP;
  END InputMatrix;
--*****************************************************************
  FUNCTION FunctionsUsingEntity (FunctionMatrix : IN
           FunctionUsingMatrix; Count: IN Integer) Return Float IS
--This function will calculate the number of functions using 2
--particular entities and compute the affinity factor of both
--entities. ie. Affinity Factor E1 to E2 = F(E1,E2)/F(E1).

    FE1, FE1E2 : Float := 0.0;
  BEGIN
    FOR I IN 1..Count LOOP
--Cells containing "c" for create and "1" for usage indicate
--associations exist
      IF (FunctionMatrix(I,1) = 'C' OR FunctionMatrix(I,1) = '1')
      AND
         (FunctionMatrix(I,2) = 'C' OR FunctionMatrix(I,2) = '1')
      THEN
        FE1E2 := FE1E2 + 1.0;
      END IF;
      IF FunctionMatrix(I,1) = 'C' OR FunctionMatrix(I,1) = '1' THEN
        FE1 := FE1 + 1.0;
      END IF;
    END LOOP;
    IF FE1 = 0.0 THEN
      RETURN (0.0);
    ELSE
      RETURN (FE1E2/FE1);
    END IF;
  END FunctionsUsingEntity;
--*****************************************************************
  PROCEDURE AffinityFactor (MatrixArray         : IN MatrixData;
                            RowCount, ColCount : IN Integer;
                            AffinityMatrix      : OUT FactorMatrix)
IS
    TempMatrix : FunctionUsingMatrix;
--Sub-module to calculate the affinity factor for each pair of
--entity in the association matrix, such that:
--F(E1) = no. of functions using entity E1, and
--F(E1,E2) = no. of functions using both entities E1 and E2.
--Therefore, Affinity Factor of E1 to E2 = F(E1,E2)/F(E1).
--For all combination of entity pairs, where E1 /= E2.
  BEGIN
-- Initialise matrix to zero
    FOR I IN 1..ColCount LOOP
      FOR J IN 1..ColCount LOOP
        AffinityMatrix(I,J) := 0.0;
      END LOOP;
    END LOOP;
    FOR I IN 1..ColCount LOOP
      FOR J IN 1..ColCount LOOP
```

```
        IF I /= J THEN -- diagonal will have zero values
--Invoke a function that will calculate and return the affinity
--factor
          FOR K IN 1..RowCount LOOP
            TempMatrix(K,1) := MatrixArray(K,I);
          END LOOP;
          FOR K IN 1..RowCount LOOP
            TempMatrix(K,2) := MatrixArray(K,J);
          END LOOP;
          AffinityMatrix(I,J) := FunctionsUsingEntity(FunctionMatrix
                                  => TempMatrix, Count => RowCount);
        END IF;
      END LOOP;
    END LOOP;
  END AffinityFactor;
--*****************************************************************
  PROCEDURE PrintSubHeading (StartCol, MaxCol, Pg, Tpg : IN Integer)
  IS
--This sub-module will print the sub-headings, top and side, of the
entity cluster matrix
  BEGIN
    IF Pg > 1 THEN
      New_Page;
    END IF;
    FOR I IN 1..65 LOOP -- right-justified to put Page number
      Put(Blank);
    END LOOP;
    Put(Item => "Page: ");
    Put(Item => Pg);
    Put(Item => " of ");
    Put(Item => Tpg);
    New_Line(2);
    Put(Item => "     "); --align 5 spaces
    FOR I IN 1..MaxCol LOOP
      IF I+StartCol-1 < 10 THEN
        Put(Item => " ");  -- align entity header right
      END IF;
      Put(Item => " E");
      Put(Item => I+StartCol-1);
      Put(Item => " ");
    END LOOP;
    New_Line;
    Put(Item => "     "); --align 5 spaces
    FOR J IN 1..MaxCol*5 LOOP
      Put(Item => '-');
    END LOOP;

  END PrintSubHeading;
--*****************************************************************

  PROCEDURE PrintEntityMatrix (AffinityMatrix : IN FactorMatrix;
                               ColCount       : IN Integer) IS
--Sub-module to print Entity Affinity Matrix
--This procedure assumes the no. of entities does not exceed 100
    Underscores : CONSTANT String := "-";
    Page : Integer; -- page control for maximum column printing
    MaxPrint : Integer;
  BEGIN
    Put(Item => "Affinity Analysis Result");
    New_Line;
    New_Line;
    Put(Item => "Association from which the Affinity Analysis is
```

```
        based");
    New_Line;
    Put(Item => "      Function involves Entity Type");
    New_Line;
    New_Line;
--To determine the number of matrix pages to print (max. 75 column
--page)
    IF ColCount*5 REM 75 = 0 THEN
      Page := ColCount*5/75;
    ELSE
      Page := ColCount*5/75 + 1;
    END IF;
    FOR I IN 1 .. Page LOOP
      IF I = Page THEN --check last page column print
        IF ColCount*5 REM 75 /= 0 THEN
          PrintSubHeading(15*(I-1)+1, ColCount-((I-1)*15), I, Page);
          MaxPrint := ColCount; --set max print to be the last
                                --entity column
        ELSE
          PrintSubHeading(15*(I-1)+1, 15, I, Page);
          MaxPrint := Page * 15; --set last print to the max. 15
                                 --entities/page
        END IF;
      ELSE
        PrintSubHeading(15*(I-1)+1, 15, I, Page);
        MaxPrint := I * 15; --set max print to the max. 15
                            --entities/page range
      END IF;
      New_Line;
--Print content of Affinity Matrix
      FOR J IN 1..ColCount LOOP --print all rows
        Put(Item => " E"); --print side entity header
        Put(Item => J);
        IF J < 10 THEN
          Put(Item => "  |");
        ELSE
          Put(Item => " |");
        END IF;
        FOR K IN 15*(I-1)+1..MaxPrint LOOP
          IF J = K THEN
            Put(Item => " == |"); -- print spaces for same entity
                                  --pair
          ELSE
            IF AffinityMatrix(J,K) = 0.0 THEN
              Put(Item => " 0  |"); -- print 0 if value is 0.0
            ELSE
              Put(Item => AffinityMatrix(J,K), Fore=>0, Aft=>2);
              Put(Item => "|");
            END IF;
          END IF;
        END LOOP;
        New_Line;
        Put(Item => "     ");
        FOR M IN 15*(I-1)+1 .. MaxPrint LOOP
          Put(Item => "|----");
        END LOOP;
        Put(Item => "|");
        New_Line;
      END LOOP;
      New_Line;
    END LOOP;
  END PrintEntityMatrix;
```

```
--*******************************************************************
  PROCEDURE PrintObjectName (ObjectType   : IN Character;
                             ObjectArray  : IN FunctionEntityArray;
                             MaxCount     : IN Integer) IS
--Sub-module to print a list of objects (functions or entities).
--Assumed to be not more than 100 objects.

  BEGIN
    New_Line;
    New_Line;
    IF ObjectType = 'E' THEN
      Put(Item => "Entity Names");
      New_Line;
      Put(Item => "============");
    ELSIF ObjectType = 'F' THEN
      Put(Item => "Function Names");
      New_Line;
      Put(Item => "==============");
    END IF;
    New_Line;

    FOR I IN 1..MaxCount LOOP
      Put(Item => ObjectType);
      Put(Item => I);
      IF I < 10 THEN
        Put(Item => " : ");
      ELSE
        Put(Item => ": ");
      END IF;
      Put_Line(Item => ObjectArray(I));
    END LOOP;
    New_Line;
  END PrintObjectName;

--*******************************************************************
------------------CLUSTERING ALGORITHM-----------------------------
  PROCEDURE SortFactor(FactorsOrdered : IN OUT OrderedListArray) IS
  -- This sub-module will perform a modified Simple Insertion Sort
  -- by inserting the OrderedFactor record with the highest affinity
  -- factor and `sliding' the remaining unordered factors to the
  -- `right` of the OrderedFactor array.
  -- Two keys will be used for the sorting: (1) AffinityFactorR that
  -- looks at the reverse entity pair (symmetric pair) and determine
  -- the priority, and (2) AffinityFactor that determines that
  -- entity pair in its natural order.
  -- This will ensure that those pairs having the same affinity
  -- factor will be prioritised according to their reverse factor,
  -- hence always ensuring highly related pairs get top priority.
    Low          : CONSTANT Positive := FactorsOrdered'First;
    High         : CONSTANT Positive := FactorsOrdered'Last;
    NextValueRec : PriorityList;
    Pos          : Positive;
  BEGIN
  -- First round sort the reverse entity pair factor
    FOR K IN Low+1 .. High LOOP
      NextValueRec := FactorsOrdered(K);
      Pos := K;
  -- scan down through array to find the insertion position
      WHILE Pos > Low AND THEN FactorsOrdered(Pos-1).AffinityFactorR
                                 < NextValueRec.AffinityFactorR

      LOOP
        Pos := Pos - 1;
```

```
    END LOOP;
    IF Pos /= K THEN
-- NextValueRec is not already in correct place, so 'slide' the
-- record elements one place to the right and insert NextValueRec
      FactorsOrdered(Pos+1..K) := FactorsOrdered(Pos..K-1);
      FactorsOrdered(Pos) := NextValueRec;
    END IF;
  END LOOP;
-- Repeat descending sort, this time with the natural entity pair
-- affinity factor
  FOR K IN Low+1 .. High LOOP
    NextValueRec := FactorsOrdered(K);
    Pos := K;
-- scan down through array to find the insertion position
    WHILE Pos > Low AND THEN FactorsOrdered(Pos-1).AffinityFactor
                          < NextValueRec.AffinityFactor
    LOOP
      Pos := Pos - 1;
    END LOOP;
    IF Pos /= K THEN
-- NextValueRec is not already in correct place, so 'slide' the
-- record elements one place to the right and insert NextValueRec
      FactorsOrdered(Pos+1..K) := FactorsOrdered(Pos..K-1);
      FactorsOrdered(Pos) := NextValueRec;
    END IF;
  END LOOP;
END SortFactor;
--*****************************************************************
PROCEDURE FormNucleiCluster(FactorRecord    : IN PriorityList;
                            NucleiCluster   : IN OUT ClusterType;
                            MaxCluster      : IN OUT Integer;
                            EntityI         : IN OUT
                            EntityIncArray) IS
-- A nuclei cluster contains the first pair of entity.  So when a
-- nuclei cluster is formed, only 2 elements exist.
BEGIN
  MaxCluster := MaxCluster + 1;
  NucleiCluster(MaxCluster).ClusterElement(1) :=
                                      FactorRecord.EntityRow;
  NucleiCluster(MaxCluster).ClusterElement(2) :=
                                      FactorRecord.EntityCol;
  NucleiCluster(MaxCluster).LastElement := 2;
  EntityI(FactorRecord.EntityRow) := 'I';
  EntityI(FactorRecord.EntityCol) := 'I';
END FormNucleiCluster;
--*****************************************************************
FUNCTION InNucleiCluster(NucleiCluster    : ClusterType;
                         MaxCluster       : Integer;
                         FactorRecord     : PriorityList)
                         RETURN Boolean IS
-- This function will test whether an entity pair already exists
-- in a nuclei cluster.  If either one of the 2 element exists,
-- the function will return a 'true' value.  Otherwise a 'false'
-- value is returned.
BEGIN
  FOR Cluster IN 1 .. MaxCluster LOOP
    FOR Element IN 1 .. 2 LOOP -- nuclei cluster occupy the 1st 2
                               -- elements
      IF FactorRecord.EntityRow =
         NucleiCluster(Cluster).ClusterElement(Element)
      OR FactorRecord.EntityCol =
         NucleiCluster(Cluster).ClusterElement(Element)
```

```
      THEN
        RETURN(True);
      END IF;
    END LOOP;
  END LOOP;
  RETURN(False);
END InNucleiCluster;
--*****************************************************************
FUNCTION ThisCluster(NucleiCluster    : ClusterType;
                     FactorRecord     : PriorityList;
                     MaxCluster       : Integer) RETURN Integer IS
-- This function will return the cluster number whose nucleus
-- element is one of the element pair in the prioritised list.
BEGIN
  FOR Cluster IN 1 .. MaxCluster LOOP
    FOR Element IN 1 .. 2 LOOP
      IF FactorRecord.EntityRow =
         NucleiCluster(Cluster).ClusterElement(Element)
      OR FactorRecord.EntityCol =
         NucleiCluster(Cluster).ClusterElement(Element)
      THEN
        RETURN(Cluster);
      END IF;
    END LOOP;
  END LOOP;
  RETURN(0);
END ThisCluster;
--*****************************************************************
FUNCTION WeightedAffinity(TempMatrix     : FunctionUsingMatrix;
                          Count          : Integer;
                          AMatrix        : FactorMatrix;
                          ECap           : Integer;
                          Ex, Ey         : Integer) RETURN Float IS
-- This function calculates the weighted affinity of ECap (the
-- candidate entity) to the original entity pair Ex and Ey in
-- nuclei cluster such that:
-- Weighted Affinity = ((affinity factor of ECap to Ex) * F(Ex) +
--                      (affinity factor of ECap to Ey) * F(Ey)) /
--
                        (F(Ex) + F(Ey))
  FEx, FEy : Float := 0.0;
BEGIN
  FOR I IN 1 .. Count LOOP
    IF TempMatrix(I,1) = 'C' OR TempMatrix(I,1) = '1' THEN
      FEx := FEx + 1.0;
    END IF;
    IF TempMatrix(I,2) = 'C' OR TempMatrix(I,2) = '1' THEN
     FEy := FEy + 1.0;
    END IF;
  END LOOP;
  IF FEx + FEy = 0.0 THEN
    RETURN(0.0);
  ELSE
    RETURN((AMatrix(ECap,Ex) * FEx + AMatrix(ECap,Ey) * FEy) /
           (FEx + FEy));
  END IF;
END WeightedAffinity;
--*****************************************************************

PROCEDURE PerformEntityClustering(NewCluster, Symmetry, AddTo,
                                  Usable : IN Float;
                                  MatrixArray    : IN MatrixData;
```

```
                                    RowCount       : IN Integer;
                                   AffinityMatrix : IN FactorMatrix;
                                   ClusterMatrix  : OUT ClusterType;
                                   LastCluster    : OUT Integer) IS
-- This sub-module, which is a main module to implement the
-- clustering algorithm, will call a sort routine to prioritise
-- the affinity factors in descending order and for each pair of
-- entities in the prioritised list will determine whether a new
-- cluster (nuclei) be created.  If one of the pair is already
-- included in a cluster, the algorithm will proceed to decide
-- whether the other element pair is a candidate for inclusion in
-- same nuclei cluster.  A criterion is the weighted affinity
-- factor of the candidate must be greater than the remaining
-- affinity factor in the priority list.
  OrderedFactor: OrderedListArray;
  MaxEntity     : CONSTANT Positive := AffinityMatrix'Last; -- no.
                                                          of row/col
  EntityInc     : EntityIncArray := (1..MaxEntity => 'X'); -- array
        -- of entity with 'I' to mean already included in cluster.
  OrderedRow    : Integer := 0;
  ClusterNum    : Integer;
  CandidateEntity : Integer;
  TempFunctionEntity : FunctionUsingMatrix;
  Treshold      : Integer := 1;  --holds the index of OrderedFactor
                           --where its affinity value is at least 60%
  Reached       : Boolean := False;

BEGIN
-- assign entity rows, entity cols, affinity factors from
-- AffinityMatrix
-- to orderedFactor (still unordered)
  FOR I IN 1..MaxEntity LOOP
    FOR J IN 1..MaxEntity LOOP
      IF I /= J THEN -- skip diagonal values
        OrderedRow := OrderedRow + 1;
        OrderedFactor(OrderedRow).EntityRow := I; --Store Entity
                                                  --row no.
        OrderedFactor(OrderedRow).EntityCol := J; --Store Entity
                                                  --col no.
        OrderedFactor(OrderedRow).AffinityFactor :=
                                              AffinityMatrix(I,J);
        OrderedFactor(OrderedRow).AffinityFactorR :=
                         AffinityMatrix(J,I); --the reverse factor
      END IF;
    END LOOP;
  END LOOP;

-- to sort AffinityFactor in OrderedFactor in descending order
  SortFactor(FactorsOrdered => OrderedFactor);

-- to determine a threshold value in which to include entities
-- whose affinity factors are at least the Minimum Usable
-- Threshold
  WHILE NOT Reached LOOP
    IF OrderedFactor(Treshold).AffinityFactor >= Usable THEN
      Treshold := Treshold + 1;
    ELSE
      Reached := True;
    END IF;
  END LOOP;
  Treshold := Treshold - 1;
```

```
-- Create first nuclei cluster containing 1st 2 elements of the
-- highest pair
   ClusterMatrix(1).ClusterElement(1) :=
                                  OrderedFactor(1).EntityRow;
   ClusterMatrix(1).ClusterElement(2) :=
                                  OrderedFactor(1).EntityCol;
   ClusterMatrix(1).LastElement       := 2; -- 2 elements in
                                            -- cluster 1

   EntityInc(OrderedFactor(1).EntityRow) := 'I';
   EntityInc(OrderedFactor(1).EntityCol) := 'I';

   LastCluster := 1; -- initialise last cluster created thus far
-- Beginning with next  highest factor value in OrderedFactor,
-- check entity pair exists in ClusterMatrix.  If not form a new
-- nuclei cluster. Otherwise determine weighted affinity of
-- candidate entity to nuclei pair and compare against next
-- highest OrderedFactor.
   FOR I IN 2..Treshold LOOP
     IF Not InNucleiCluster(NucleiCluster => ClusterMatrix,
MaxCluster => LastCluster, FactorRecord => OrderedFactor(I))
     AND EntityInc(OrderedFactor(I).EntityRow) = 'X'
     AND --both entities not yet included.
         EntityInc(OrderedFactor(I).EntityCol) = 'X' THEN
       IF AffinityMatrix(OrderedFactor(I).EntityRow,
          OrderedFactor(I).EntityCol) >= NewCluster
       AND --higher than minimum New Cluster Affinity
          AffinityMatrix(OrderedFactor(I).EntityCol,
          OrderedFactor(I).EntityRow) >= Symmetry
       THEN --higher than minimum Symmetry Affinity
             FormNucleiCluster(FactorRecord => OrderedFactor(I),
             NucleiCluster => ClusterMatrix, MaxCluster =>
             LastCluster, EntityI => EntityInc);
       END IF;
     ELSE
       ClusterNum := ThisCluster(NucleiCluster => ClusterMatrix,
                     FactorRecord => OrderedFactor(I),
                     MaxCluster => LastCluster); -- cluster no.
               --of nuclei to compare against candidate pair
       IF ClusterNum > 0 THEN --cluster not found to include (=0)
-- because entity is not one of nuclei but one of element
-- Determine which entity pair in OrderedFactor(I) to include
         IF OrderedFactor(I).EntityRow =
                ClusterMatrix(ClusterNum).ClusterElement(1)
         OR
            OrderedFactor(I).EntityRow =
                ClusterMatrix(ClusterNum).ClusterElement(2)
         THEN
            CandidateEntity := OrderedFactor(I).EntityCol;
--Candidate is EntityCol
         ELSE
           CandidateEntity := OrderedFactor(I).EntityRow;
--Candidate is EntityRow
         END IF;
         IF EntityInc(CandidateEntity) = 'X' THEN
--not yet included in cluster
--Slide portion of MatrixArray containing nuclei pair in a
--temporary FunctionEntity matrix to count the no. of function
--usage
           FOR M IN 1 .. RowCount LOOP
             TempFunctionEntity(M,1) :=
MatrixArray(M,ClusterMatrix(ClusterNum).ClusterElement(1));
```

```
            TempFunctionEntity(M,2) :=
MatrixArray(M,ClusterMatrix(ClusterNum).ClusterElement(2));
          END LOOP;
 -- Calculate weighted affinity of CandidateEntity to nuclei pair
          IF WeightedAffinity(TempFunctionEntity, RowCount,
               AffinityMatrix, CandidateEntity,
               ClusterMatrix(ClusterNum).ClusterElement(1),
               ClusterMatrix(ClusterNum).ClusterElement(2))
               > Addto THEN
 -- Include Candidate entity if the weighted factor is higher than
 -- Minimum Add To Cluster Affinity
 -- Include Candidate entity only if the weighted affinity is
 -- higher than the next affinity factor in the ordered list.
            ClusterMatrix(ClusterNum).LastElement :=
                        ClusterMatrix(ClusterNum).LastElement + 1;
 -- increment the no. of elements in cluster.

ClusterMatrix(ClusterNum).ClusterElement(ClusterMatrix(ClusterNum).
            LastElement) := CandidateEntity;
            EntityInc(CandidateEntity) := 'I';
          END IF;
        END IF;
      END IF;
    END IF;
  END LOOP;
 END PerformEntityClustering;

--*****************************************************************
 PROCEDURE PrintEntityCluster(ClusterMatrix : IN ClusterType;
                              ObjectArray   : IN
FunctionEntityArray;
                              LastCluster   : IN Integer;
                              NCluster, Sym, ATo, Uable : IN Float;
                              AM, ON, C     : IN Boolean) IS
--This sub-module prints the result of the entity clustering.  Each
--cluster contains a group of entities closely coupled according to
--their affinity values and this is printed along with the list of
--entities.
   LastObject   : CONSTANT Positive := ObjectArray'Last;

 BEGIN
   New_Line(2);
   Put(Item => "   i.  Minimum New Cluster Affinity     = ");
   Put(Item => NCluster*100.0, Fore => 3, Aft => 0);
   New_Line;
   Put(Item => "   i.  Minimum Symmetric Affinity       = ");
   Put(Item => Sym*100.0, Fore => 3, Aft => 0);
   New_Line;
   Put(Item => "  ii.  Minimum Add To Cluster Affinity  = ");
   Put(Item => ATo*100.0, Fore => 3, Aft => 0);
   New_Line;
   Put(Item => " iii.  Minimum Usable Affinity          = ");
   Put(Item => Uable*100.0, Fore => 3, Aft => 0);
   New_Line(3);
   Put(Item => "Print Options:");
   New_Line(2);
   Put(Item => "   i.  Print Affinity Matrix? (Y/N)     = ");
   IF AM THEN
     Put(Item => "Yes");
   ELSE
     Put(Item => "No");
   END IF;
```

```
    New_Line;
    Put(Item => "  ii.  Print Object Names? (Y/N)          = ");
    IF ON THEN
      Put(Item => "Yes");
    ELSE
      Put(Item => "No");
    END IF;
    New_Line;
    Put(Item => " iii.  Print Clusters? (Y/N)              = ");
    IF C THEN
      Put(Item => "Yes");
    ELSE
      Put(Item => "No");
    END IF;
    New_Line(2);

    FOR I IN 1..LastCluster LOOP
      Put(Item => "Cluster ");
      Put(Item => I);
      Put(Item => " (Containing nuclei entities E");
      Put(Item => ClusterMatrix(I).ClusterElement(1)); --print
                                                       --nuclei entities
      Put(Item => " and E");
      Put(Item => ClusterMatrix(I).ClusterElement(2));
      Put(Item => ")");
      New_Line;
      New_Line;
      --Print list of entities in the cluster
      FOR J IN 1..ClusterMatrix(I).LastElement LOOP
        Put(Item => "        E");
        Put(Item => ClusterMatrix(I).ClusterElement(J));
        Put(Item => "  ");
      --Locate and print entity description in ObjectArray
        Put(Item =>
                  ObjectArray(ClusterMatrix(I).ClusterElement(J)));
        New_Line;
      END LOOP;
      New_Line;
    END LOOP;
  END PrintEntityCluster;
--*******************************************************************
-- Declaration of main program variables
  EntityCluster: ClusterType; -- hold result of entity clustering
-- array of functions; initialise to spaces
  Functions     : FunctionEntityArray(1..MaxRow) :=
                       (1..MaxRow => (1..MaxNameLen+1 => Blank));
-- array of entities; initialise to spaces
  Entity        : FunctionEntityArray(1..MaxCol) :=
                       (1..MaxCol => (1..MaxNameLen+1 => Blank));
--For inputting 2-D matrix
  Matrix        : MatrixData;
--Entity matrix for clustering
  EntityMatrix : FactorMatrix;

  FunctionCount, EntityCount : Integer; --actual no. of
                                        --function/entity objects
  LastClusterNum : Integer;
  MinNew, Symmetric, MinAddTo, MinUsable : Float; --threshold values
                                                  --for clustering
  PrintAM, PrintON, PrintC  : Boolean; --options to print Affinity
                              --Matrix, Object Names and Clusters
```

```
--*******************************************************************
--Main Program

BEGIN
--user interface for threshold and printing options
  Options(NewC => MinNew, Symm => Symmetric, AddC => MinAddTo, UseC
          => MinUsable, Print_AM => PrintAM, Print_ON => PrintON,
             Print_C => PrintC);

--Open I/O files
  OpenInput(FileName => "Function.dat");
  OpenOutput(FileName => "AffinityResult.txt");

--Read in object Function data
  InputObject(ObjectArray => Functions, Count => FunctionCount);
  CloseInput;
--Read in object Entity data
  OpenInput(FileName => "Entity.dat");
  InputObject(ObjectArray => Entity, Count => EntityCount);
  CloseInput;
--Read in Function-Entity Association Matrix (2-Dimensional)
  OpenInput(FileName => "Matrix.dat");
  InputMatrix(MatrixArray => Matrix, RowCount => FunctionCount,
                                       ColCount => EntityCount);

--Calculate Affinity Factor
--Form Entity Matrix by storing Affinity Factor in affinity matrix
  AffinityFactor(MatrixArray => Matrix, RowCount => FunctionCount,
                 ColCount => EntityCount, AffinityMatrix =>
                 EntityMatrix);

  IF PrintAM THEN
  --Print Entity Matrix in AffinityResult.txt
    PrintEntityMatrix(AffinityMatrix => EntityMatrix, ColCount =>
                      EntityCount);
  END IF;

  IF PrintON THEN
  --Print list of Entity names
    PrintObjectName(ObjectType => 'E', ObjectArray => Entity,
                    MaxCount => EntityCount);
  --Print list of Function names
    PrintObjectName(ObjectType => 'F', ObjectArray => Functions,
                    MaxCount => FunctionCount);
  END IF;

  IF PrintC THEN
  --Perform entity clustering on EntityMatrix
  --Clustering algorithm is performed in this sub-module and sub-sub
  --modules contained within it.
    PerformEntityClustering(NewCluster => MinNew, Symmetry =>
Symmetric, AddTo => MinAddTo, Usable => MinUsable, MatrixArray =>
Matrix, RowCount => FunctionCount, AffinityMatrix => EntityMatrix,
ClusterMatrix => EntityCluster,
LastCluster => LastClusterNum);

  --Print EntityCluster
    PrintEntityCluster(ClusterMatrix => EntityCluster, ObjectArray
      => Entity, LastCluster => LastClusterNum, NCluster => MinNew,
      Sym => Symmetric, ATo => MinAddTo, Uable => MinUsable, AM =>
      PrintAM, ON => PrintON, C => PrintC);
```

```
  END IF;

--Close I/O file
  CloseInput;
  CloseOutput;
END Affinity_Analysis;
```