An Empirical Investigation Of The Factors Contributing To Spreadsheets Usage And End-User Computing Satisfaction

by

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ABSTRACT

The purpose of this research is to develop and test a model of the relationships between several external and various mediating variables and the end-users' satisfaction and usage of spreadsheets.

The present research takes several steps toward establishing a valid motivational model of the end-users. Two fairly general, well-established theoretical models (i) 'theory of reasoned action' (TRA) of human behaviour from social psychology and (ii) 'technology acceptance model' (TAM) from management information systems were chosen as paradigms within which to formulate an extended model. Several adaptations to these paradigms were introduced in order to make them applicable to the present context building upon and integrating previous research in a cumulative manner.

This led to a model which was tested by a nine page questionnaire with 129 entries. Response data was collected from a cross-sectional survey of 333 university students who have been out for one year training in industry across the UK.

A careful reliability and validity analysis for the measures used in the survey was conducted. Multiple regression analysis, path analysis, and LISREL modelling were used as different data analysis techniques. The analysis in part gave good support for the initial model considered but also indicated some shortcomings in the two base models.

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Chapter 1

INTRODUCTION

Significant shifts have taken place in the world of information systems (IS) over the past two decades. Fifteen years ago, the IS function maintained a virtual monopoly over the acquisition, deployment, and operation of an organisation's information resources. Today, most of these responsibilities have been transferred to end users with the trend towards end-user computing (EUC).

The tremendous growth of microcomputers and EUC represents a significant development in the field of management information systems (MIS). An estimate in the UK predicted that the ratio of computer terminals or microcomputers to office workers was already approaching an average of one to one (Stewart 1990). Knowledge workers are likely to have their own microcomputer to perform both stand-alone tasks and network services.

Virtually every microcomputer or personal computer (PC) has spreadsheet software installed as standard. Spreadsheets have probably been the single most important influence driving the spread of microcomputers to all areas of business (Mason and Keane 1989). The widespread use of spreadsheet packages by accountants is a well known phenomena, and in a typical study Carr (1985) showed that spreadsheet packages were used by about three-quarters of all UK accountants, more than any other type of computer software.

The potential problems of the explosion in end user computing, fuelled by spreadsheet packages, have been a motivating factor for some of the research in model management and EUC. For instance, the statement by Dolk and Knosynki (1985) that "the rampant proliferation of spreadsheets has caused major headaches for management" has highlighted the need for research to ease the situation and thus provide some remedy. Similarly, the review of model management research by Baldwin et al (1991) sheds light on the problem of spreadsheet packages.

Computer-based information systems are viewed as important in contemporary society, but problematic in terms of interpreting their meaning and value (Walsham 1993). Despite this tremendous growth in end-user computing, we know relatively little about the forces that influence utilization of personal computers (Thompson et al, 1991). This is likely to be true, not only for personal computers, but also for end-user computing facilities and resources, specifically including spreadsheets.

This thesis takes spreadsheets, as an important end-user system in the EUC domain, as its particular focus. Rather than include all related matters to the adoption of spreadsheets, the study centered on user acceptance of spreadsheets. User acceptance of spreadsheets was looked at from two angles: usage and satisfaction as major indicators of user acceptance. Throughout this thesis "user acceptance" will be taken to refer to usage or user satisfaction or both, whereas "adoption" includes consideration of implementation issues which might eventually lead to diffusion.

Aims of The Study

Computer systems can not improve organisational performance if they are not used. End users are often unwilling to use available computer systems that, if used, would generate significant gain (Alavi and Henderson 1981; Nickerson 1981; Swanson 1988). Unfortunately, resistance to end-user systems by managers and professionals is a widespread problem (Davis et al 1989). The acceptance of information technology (IT) has become a fundamental part of the MIS research plan for most organisations (Igbaria 1993). A better understanding of the factors contributing to the acceptance or rejection of information technology is the first step toward the solution of the problem.

Acceptance and voluntary use of information technology by managerial, professional, and operating level personnel as users is deemed a necessary condition for its success; however, resistance to computer systems by managers and professionals is a widespread problem (Attewell and Rule 1984; Davis et al 1989; Igbaria and Chakrabarti 1990). Davis (1993) argues that lack of user acceptance has long been an impediment to the success of information systems which, if avoided, would improve performance on the job which is the goal of most organisationally based information systems.

User acceptance is often the pivotal factor and a central focus of MIS implementation research in determining the success or failure of an information technology product (Swanson 1988; Davis et al 1989; Thompson et al 1991; Davis 1993; Igbaria 1993). Availability of information technology does not necessarily lead to its acceptance. Most information system failures result from a lack of user acceptance rather than poor quality of the system (Torkzadeh and Angulo 1992, Igbaria 1993, Davis 1993).

The focus of this research is on the underlying reasons behind end users' acceptance or rejection of spreadsheets. Thus the important question that is addressed in this study is:

> **What are the factors that contribute to spreadsheets usage and end-user computing satisfaction (EUCS) in organisational settings?**

Previous research into user acceptance of information technology has mainly concentrated on users' attitudes toward acceptance while neglecting the role of norms in the workplace. It was also noticed that few IT characteristics were researched and these were not approached in a coherent manner (e.g., Davis 1986, Davis et al 1989, Thompson et al 1991, Igbaria 1993, Davis 1993). Thus, it was recognised that the study would need to consider a broad range of IT characteristics and investigate the normative side of the equation besides that of attitudes toward usage.

Moreover, most previous research measured usage as a surrogate measure for user acceptance. This study aims to consider both usage and satisfaction as dual measures of user acceptance of spreadsheets.

Need For The Study

As spreadsheets play an important role in the explosion of EUC across organisations, end-users' acceptance behaviour needs to be understood in order that sound guidance based on empirical observations can be offered to these organisations. A greater understanding of the factors that impact this behaviour could help organisations develop appropriate spreadsheets adoption strategies. What little research there has been on EUC acceptance is general and this study aims to expand this field by probing the end-users' acceptance of spreadsheets in organisational settings.

To date, research investigating the relationship between attitude and computer utilization is one area where many IS researchers have been remiss in not using existing models or theories, particularly those from the social psychology literature (Thompson et al 1991). To redress this lack, the work described in this thesis makes a contribution to the theory of implementation of computer-based systems. Fishbein and Ajzen's model, which originated in the psychology discipline (and has also been used successfully in other disciplines) to predict behaviour from attitudes, is used in this study. If this model is found to apply in an MIS setting, it opens up a line of behavioural research in MIS dealing with norms and attitudes toward systems. It has been argued that research on behavioural issues in MIS does not have a strong theoretical base, and therefore results in inconsistent findings (Lucas 1978).

This area of research is also important to practitioners. Organisations are becoming more cautious about microcomputers and related software acquisitions. Top management are starting to realize that effective policies are required to enable organisations to better control microcomputer use, and obtain the benefits makes end users (managers and professionals) decide to use available EUC facilities in their jobs. A better understanding of why certain end users use them while others do not, is a first step towards understanding how to motivate managers and professionals to use them more effectively.

Research Methods

Following an extensive review of the literature, which is reported in Chapter 2, the research went through three successive stages:

I. building the research framework;
II. research design;
III. analysis.

The first stage provided the research framework for the study based on a theory from social psychology and an application model of it in MIS. The second stage led to the choice of the 'self-administered questionnaire' as a suitable research strategy and to a definition of the study sample. This stage provided the research data from 333 eligible end users from university finalist students who had one year's experience in industry. The third stage analysed the data using three different analysis techniques of varying levels of sophistication.

The research framework is discussed in Chapter 3. The research design and use of the self-administered questionnaire are discussed in Chapters 4 and 5. The analysis of the data is the focus of Chapters 6, 7, 8, 9, and 10.

Research Framework

Viewing IT acceptance as an user behaviour enabled IS researchers to assimilate some models from social psychology in order to predict the determinants of user acceptance of IT. The technology acceptance model (TAM), was first introduced by Davis in 1986. TAM is an adaptation of the theory of reasoned actions (TRA) taken from the social psychology discipline which is concerned with the determinants of consciously intended behaviours (Ajzen and Fishbein 1980; Fishbein and Ajzen 1975). The goal of TAM is to provide an explanation of the determinants of computer acceptance that is general, and thus capable of explaining user behaviour across a broad range of end-user computing technologies and user population (Davis et al 1989). TRA and TAM are discussed in Chapter 3 as they provided the research framework of this study. Ten research hypotheses are derived and these are also discussed in Chapter 3.

Research Design

Research design is the focus of Chapter 4, and this draws on Dillman's comparison of three questionnaire approaches (Dillman 1978). This study implemented the self-administered questionnaire approach as it was considered the most suitable from among the choice of three. The content and development of the questionnaire is reported in Chapter 5. Reliability and validity tests for the scales used in the questionnaire are discussed in Chapter 7.

Analysis of Survey Questionnaire Data

Rather than use a single statistical method of analysis, a number of methods were employed. This analysis of the questionnaire data is reported in Chapters 6, 8, 9, and 10. Various descriptive statistics were used to indicate the nature of end users and their beliefs, attitudes, and usage behaviour in this study (Chapter 6). Testing the hypothesized causal structure of the proposed research model and the ten research hypotheses is the focus of Chapters 8 to 10. The statistical analysis drew on various methods, including correlation, multiple regression analysis, path analysis, and LISREL modelling.

Correlation and multiple regression analysis (Chapter 8) provided the basis for testing the hypothesized causal structure of the proposed research model described in Chapter 3. Path analysis was used to investigate the determinants of spreadsheets usage and EUCS employing the notion of total effect for each factor (Chapter 9). LISREL modelling was used to test the structural equation (causal) models of usage and EUCS which emerged from regression and path analysis. LISREL is a good tool in verifying 'how far the models fitted the data', a feature not provided by either of the two other methods.

Limitations Of The Study

The study did not attempt to research all types of end users. Instead, of the three broad categories of end-users, only direct users of spreadsheets with certain conditions were researched. Specifically, the types of end-users researched here are those who both develop (or modify) and use their own spreadsheets applications which might be used by others occasionally. Though findings could apply to other types of end-users within the 'direct' category, this is less likely with the other two categories: indirect and intermediate end-users.

Also, the study did not attempt to research end users in their natural settings. Instead, university final year students who have just spent one year in industry were taken as the sample. Although the students researched in this study were treated as official employees during the year in industry, keeping in mind the established support for using students in research (e.g., Latour et al 1990, Barrier and Davis 1993), it might be argued that there are some differences with end users in the organisational natural settings.

A self-administered survey questionnaire was used to gather the data for the analysis. Self-administered questionnaires have strengths as well as drawbacks. It is possible that the results contain some bias or systematic errors as a result of self-reporting.

The study did not attempt to obtain a complete picture of user acceptance by researching the quality of usage and linking that to performance. An implicit assumption in this study is that higher usage of spreadsheets will lead to better performance. The study deliberately concentrated on 'quantity' of usage as a behaviour in order to be able to relate that to users' attitudes and norms in the workplace.

Chapter 2

LITERATURE REVIEW

The initial aim of the literature review was to investigate the major factors contributing to the acceptance (satisfaction with and usage) of spreadsheets as an important IT resource. It was hoped that this would define the major thrust of the research. However, a comprehensive literature search covering 1992/1993 identified only four studies that investigated the acceptance/utilization of IT within appropriate theoretical models, and none of these had specifically looked at spreadsheets (Davis et al 1989; Thompson et al 1991; Igbaria 1993; Davis 1993).

With relatively so little prior work in the area, a broad search was conducted and the following five bodies of literature reviewed:

I. End User Computing

II. Proliferation and Prevalence of Spreadsheets

III. User Acceptance of Information Technology

IV. Information Technology Characteristics

V. Measures of User Acceptance of Information Technology

The scope of the search was limited so as not to be exhaustive but rather selective, in order to cover an acceptable amount of literature within a limited space. The reviews of each of the listed five bodies are given below.

END USER COMPUTING

Definition and growth of EUC

Benjamin (1982) established the practice of calling *applications beyond data processing departments "end-user computing" (EUC).* He specified three characteristics that were nearly always present: (1) applications were normally built by end-users who quickly build small applications to be ultimately used to do functional work (2) most early EUC applications were small and simple built by the ultimate users (3) end-users were expected to be extremely self-reliant, that is, to have limited support from DP/MIS departments.

End-user computing (EUC) is defined by Rockart and Flannery (1983) as *the ability of the ultimate users to fulfill their computational needs.* Organisations have been developing and implementing computer-based management information systems (MIS) for a relatively long time. EUC was born and evolved in the MIS environment in response to several conditions: long backlogs of requests for DP/MIS services; a better and more computer-literate user community; the advent of user-friendly software; and, ultimately, the development of the microcomputer.

End-user Computing is defined by Carr (1988) as *the direct hands-on use of computers by people with problems for which computer-based solutions are appropriate.* He reported four reasons for the high growth rate of EUC: (1) vastly increased awareness of the potential of EUC, (2) improvements in the technical capabilities that make EUC increasingly more flexible and less costly, (3) the more difficult business conditions that prevail today, and (4) the fact that users' needs cannot be satisfied through traditional IS organisations.

The growth of end-user computing is one of the significant phenomena of the 1980s in the information management world (Benson, 1983). He reported that a study by the International Data Corporation, in 1982, predicted that four out of five administrative and professional workers will be using personal computing to support their work and personal activities by 1990. Stewart (1990) in a recent estimate in the UK predicted that the ratio of computer terminals or micro-computers to office workers was already approaching an average of one to one.

We are in the second decade of end user computing within most organisations. Benjamin(1982) in his study "Information Technology in the 1990s: A Long Range Planning Scenario" predicted that by 1990, end-user computing will absorb 75% of the corporate computer resource. Rockart and Flannery (1983) observed that at each company in their study, end-user computing was growing at a rate of approximately 50% -90% per year. This was measured by either actual allocation of computer hardware power or external time-sharing budgets.

Panko (1987) argues that corporate interest in end-user computing did not begin seriously until the 'PC shock' of the early 1980s. Taking the list of important issues cited by DP managers and professional as a measure, Panko reported two surveys in 1981 and 1983 which revealed that EUC was not found among the list in 1981, but in 1983 EUC had surged to the second position among the concerns listed. This lends weight to the argument that EUC only became a significant and manifest phenomena to DP managers from around1983.

Nelson (1989) described End-user computing as a complex and highly diverse phenomenon, which has grown out of rapid advances in technology, for example:

- The introduction of the personal computer (PC) to the corporation
- Personal productivity software (e.g., spreadsheets, database management systems, and word processing)
- Fourth-generation languages
- Peripheral devices, such as mice, touch-sensitive CRTs
- Telecommunications and PC networking.

Three major forces which explain much of the motivation behind EUC are (1) hardware and software improvements have greatly increased the availability, affordability, and usability of IT (McLean 1979, Martin 1982; Davis and Olson 1985; Amoroso 1988) (2) enhanced computer-related skills within the end-user community have motivated and enabled end-users to use IT products (McLean 1979, Nelson and Cheney 1987) (3) an organisational environment conducive toward EUC has grown around the successful employment of EUC products and technologies (Alavi et al 1987).

One analyst expressed the force of end user computing in this way: "End User Programming is 'inevitable' and will bring with it the need to change the data processing organization, if not the profession itself. End User Programming is coming, because it offers just too many benefits to end users" (Carr 1988, p64).

Many researchers view EUC as "inevitable" and consider it not to be a passing phenomenon but one existing to last; this is because the development of EUC is an irreversible process (Rockart and Flannery 1983; Alavi et al 1987; Panko 1987; Carr 1988; Amoroso 1988). EUC has had a positive impact on the "bottom line" within many organisations and as a result has been viewed as a strategic weapon by top management (Alavi et al, 1987). Panko (1987), after reporting and proving numerically the progressive development of EUC, concluded that " end-user computing will soon be much larger than DP (department), if it is not already. EUC is the future of information systems. Those who fail to view it as a strategic fundamental change that will affect every thing else within IS are failing at strategic IS planning itself." (p. 6).

Nelson (1989) reported some specific lessons to be learned from twenty articles which were selected from leading sources in the field of MIS:

- EUC represents the infinite utilization of IS technology by end users;
- organisations must provide a technical and managerial infrastructure on which applications can be overlaid. To do so, such technical issues need to be coupled with managerial issues such as training and strategy formulation;
- finally, the co-existence of end-user and centralized computing requires a great deal of managerial attention.

Organizational Support for EUC

The objectives and advantages of EUC given by Carr (1988), are that "(1) more resources are applied to the application development backlog, (2) the user gets involved with the solution, not just the problem, and (3) actions replaces waiting. Benefits of EUC include (1) increased motivation and better use of professional talent, (2) timely availability of information, (3) the ability to analyze business problems more thoroughly, and (4) increased productivity of office staff, both professional and clerical" (p 64). Such advantages are worthy of considerable attention and support from organisations to adopt EUC for its benefits as a competitive advantage resource.

EUC support refers to the activities that serve to enhance the development and growth of EUC within the organisation. As stated by Davis and Olson (1985), "one of the most powerful capabilities supplied to users is the facility to develop their own applications" (p. 421). Many organisations have found that the proper mix and delivery of support activities can result in productivity gains. Examples of EUC related support activities include training and education, data access, and consulting.

One of the many user-developed activities that might still be described as relatively small in size and low in complexity are small spreadsheet models. These spreadsheet applications are mostly developed by inexperienced end users (Cragg and King 1993). Therefore, organisations need to provide a set of related activities to ensure best spreadsheeting practice to maximize the benefits and minimize the risks for their favour. Panko (1987) argued that information centres must develop a tailored management mix consisting of four components: *technological infrastructure*, *support*, *control*, and *promotion*.

The information centre (IC) is a coordinated, formalized way of supporting end user computing. It was originated and tried by IBM-Canada as a means of gaining relief from the building backlog of data services requests. With internal success, IBM presented the concept to its customers as an alternative to the stagnation being experienced in application creation (Carr 1988).

Hammond (1982) of IBM in his landmark article on ICs gives the following description and prescription:

> An Information Center (IC) is a portion of the Information Systems (IS) development resource organized and dedicated to support the users of IS services in activities such as report generation and modification, data manipulation and analysis, spontaneous inquiries, etc. The fundamental premise underlying an IC is that if provided proper education, technical support, usable tools, data availability, and convenient access to the system, users may directly and rapidly satisfy a portion of their business area requirements that depend on an IS environment...The objective of an IC is to provide users access to data on their own terms so that they can solve their own business problems. It is typically accomplished by providing a set of packaged tools and data availability (with appropriate training and consulting support) to the users enabling them to gain the power of the computer in a relatively easy and timely fashion.
>
> (Hammond, 1982: pp 131,133)

Leitheiser and Wetherbe (1986) discuss four possible MIS strategies toward EUC: (1) *sink or swim*: Do nothing -- let the end user do it; (2) *stick*: Establish policies and procedures to control EUC so that corporate risks are minimized; (3) *carrot*: Create incentives to encourage practices that reduce organisational risks; (4) *support*: Develop services to aid end users in their computing activities.

Recently, the role of IC in the growth of EUC in several organisations has been evaluated; Khan(1992) found that: (i) some of them established ICs to guide and support EUC, while others adopted a sink or swim EUC strategy; (ii) the ICs standardized on hardware and software environment, provided training and technical support to end-users; (iii) the organisations are yet to introduce control procedures to monitor EUC activities. The challenge to information systems managers is to satisfy the demands of these users while advancing an end-user computing strategy that will efficiently support the competitive position of the organisation (Henderson and Treacy 1986; Gunton 1988).

Managing EUC

Many of the user-developed applications are not personal or private in nature; that is, they are not merely used by single individuals to support his/her activities (Alavi and Weiss 1985). Bast and Chrisman (1992) reported how spreadsheets are increasingly used to support critical business decision making and are often shared by several individuals or consolidated from various segments of the organisation. For that, the need for the management of EUC seems to be well recognized, however, comprehensive and well-defined procedures do not exist in many organisations (Nelson 1989; Khan 1992).

Davis (1984), Alavi and Weiss (1985), and Cragg and King (1993) addressed the risks associated with EUC applications as they associated EUC risks with different stages of the end-user developed applications life cycle. Generic controls are then introduced in a manner that allows EUC management to select those most appropriate to their EUC environment.

The article " The Management of End-User Computing" by Rockart and Flannery (1983), is widely regarded as a "classic" in the field of EUC management. Based on interviews with 200 end users and 50 members of staffs responsible for EUC support, the authors set forth a number of managerial recommendations for EUC. Rockart and Flannery concluded in their article that, "Developing the appropriate strategy, support processes, and control processes for EUC is a staggeringly large job."

Alavi, Nelson, and Weiss (1987) attempt to address those concerns raised by Rockart and Flannery in their article, "End-User Computing Strategies: An Integrative Framework". The authors develop a framework consisting of five core strategies, or organisational postures, vis-à-vis EUC: (1) Laissez-faire (2) Monopolist (3) Acceleration (4) Marketing (5) Operations. Following a description of each of the strategies, they employ a two-step process to represent (i) how, and (ii) when to adopt a particular strategy.

The identification of variables that may affect the success of EUC facilities within an organisation is extremely important. Ein-Dor and Segev (1978) suggest a useful conceptual scheme for relating organisational context variables and MIS success. Cheney, Mann, and Amoroso (1986) adopt this scheme in their article, "Organisational Factors Affecting the Success of End-User Computing" and identify success/failure variables based on a three-part classification scheme: controllable, partially controllable, or uncontrollable. The classification permits a stepwise analysis of organisational context variables as they relate to EUC success, making the scheme useful for evaluating either existing or planned end-user computing facilities.

EUC and Spreadsheets

For organisations to avoid expensive, and scarce programmers in the development of applications, Martin (1982) suggests that end users could be given powerful tools with which they can create their own applications, as a first option among three alternatives. Spreadsheets packages were found to be the most common computer application employed as an EUC tool by managers and professionals (Benson 1983; Lee 1986; Sprague and Watson 1986; Panko 1987; Mason and Willcocks 1991; Galletta 1993).

Benson (1983) in a field study of end-user computing found that the introduction of microcomputers was triggered primarily by the same application needs of mainframe. But a striking contrast was found between the applications initially used by microcomputer users compared to mainframe users; this contrast demonstrates that analytical applications drove the introduction of microcomputers. Benson also noted, interestingly, the domination of one piece of software (VISICALC) which is a spreadsheet software product.

Based on worldwide sales revenues in 1985, Panko (1987) reported that the use of spreadsheet software systems on PCs ranked second overall among other software types. Panko commented that, "the difference with word processing software, which ranked first, was very marginal as opposed to the software that was ranked third as the difference was less than half'. This reflects the reality that spreadsheets are considered very important among EUC systems.

Spreadsheets have been used to support management decision making for many years and their availability in the end-user computing environment is a significant development (Mason and Willcocks 1991; Sutton and Faulkner 1994). It is the "what if" analysis power of spreadsheets which plays a major role in securing vast success in the battle for EUC to penetrate the chief executive suite.

It is widely accepted among researchers and practitioners that the explosion in end user computing was mainly fuelled by spreadsheet packages (Benson 1983; Lee 1986; King et al 1990; Brancheau and Wetherbe 1990; Mason and Willcocks 1991; Sutton and Faulkner 1994). Indeed, this explosion has carried forth a clear signal of the proliferation and prevalence of spreadsheets, which will be the subject of further discussion in the next section.

PROLIFERATION AND PREVALENCE OF S/S

Virtually every microcomputer or personal computer (PC) has spreadsheet software installed as standard. Spreadsheets have probably been the single most important influence driving the spread of microcomputers to all areas of business (Mason and Keane 1989). They found that for many of the managers they studied, a spreadsheet package was the only decision support tool.

Myers (1992) argues that, the most successful end-user programming systems are spreadsheets, elaborating on the reason for popularity by stating that: "spreadsheets are enormously popular for personal-computer users, and some claim that spreadsheets are the primary reason most people buy personal-computers" (p 15). Hendry and Green (1994) argue that it is certainly possible that more people "program" with spreadsheets than with any other programming environment.

King et al (1990) in a series of 16 cases showed the significance of spreadsheet packages on end-users' attitude to central computing facilities. They showed that many managers, including board-level directors, have gained independence of central control of computing facilities by the purchase of PCs and use of spreadsheet packages. These series of cases give examples of modelling and decision support being undertaken with spreadsheet packages by managers in production, purchasing, sales, marketing and engineering functions.

The use of spreadsheet packages by accountants is a well known phenomena and in a typical study Carr (1985) showed that spreadsheet packages are used by about three-quarters of all UK accountants, more than any other type of computer software. Mason and Willcocks (1991) in a series of interviews in 26 organisations found that the core technology was in fact spreadsheets on personal computers. Their sample organisations were drawn from financial services, government departments, statutory agencies, headquarters of primary producers, management and professional consultancies. This provided a useful cross-section of public and private, office-based, small and medium-sized enterprises.

Spreadsheeting grows and flourishes in an environment where professionals and managers are attracted to spreadsheet packages because they are "apparently" cheap, "apparently" easy to learn and quickly provide results in a form readily appreciated by them, moreover, they are also valued because they enable managers to be independent of Finance Directors and MIS departments and to adopt a Do-it-Yourself approach to systems development (King et al 1991).

The study by Lee (1986) shows that spreadsheets are prevailing as about three-quarters (74%) of his sample of 311 PC users were spreadsheet users. Some of this use may be for trivial purposes, but other studies show that spreadsheets are used for serious applications. Eom and Lee (1990) analysed decision support systems (DSS) applications published between 1971 and 1988, and identified about 12% of specific DSS as being based on spreadsheet modelling — spreadsheets were first in use in 1980, making a span of 9 years for the reported ratio in effect.

The use of spreadsheet packages has also become important within the UK Operational Research Society members and management scientists. Cornford and Doukidis (1991) show spreadsheet packages as the most frequently used or supported computer software in an investigation of the use of computers within operational research. Clark (1992) reports spreadsheets to be the 6th most popular management science tool is strategic planning.

Cragg and King (1993) give insight as to how far spreadsheet packages have become popular by stating that, "it is interesting to note that the use of spreadsheets has moved beyond these well-publicized areas of application into a role of interactive optimization, decision analysis, marketing segmentation, economic modelling as well as manpower planning" (p. 744). To give but a few examples of the wide proliferation of spreadsheets use: optimization (Roy et al 1989 and Sutton & Faulkner, 1994); decision analysis (Jones, 1986); stochastic simulation (Seila & Banks, 1990 and Przasnyski, 1994); forecasting (Mumford et al, 1991); market segmentation (Winter, 1989); manpower planning (Anthony & Wilson, 1990); and costing (Wellman, 1992).

From the previous review it is fair to conclude that; the rapid and sustained invasion of spreadsheets into modern organisation provides clear evidence of the proliferation and prevalence of it as an important IT product. Consequently, looking at the major factors contributing to user acceptance of spreadsheets is an important area of investigation. The next section starts this process by discussing how users accept information technology in general.

USER ACCEPTANCE OF INFORMATION TECHNOLOGY

Acceptance and voluntary use of information technology by managerial, professional, and operating level personnel as users is deemed a necessary condition for its success, and resistance to computer systems by managers and professionals is a widespread problem (Attewell and Rule 1984; Davis et al 1989; Igbaria and Chakrabarti 1990). Davis (1993) argues that lack of user acceptance has long been an impediment to the success of information systems which if avoided would improve performance on the job as the goal of most organisationally based information systems.

User acceptance is defined by Swanson (1988) to be: *Potential user's pre-disposition toward personally using a specific system.* User acceptance is often the pivotal factor and a central focus of MIS implementation research in determining the success or failure of an information technology product (Swanson 1988; Davis et al 1989; Thompson et al 1991; Davis 1993; Igbaria 1993). Availability of information technology (IT) does not necessarily lead to IT acceptance. Most information system failures result from a lack of user acceptance rather than poor quality of the system (Torkzadeh and Angulo 1992).

End users are often unwilling to use available computer systems that, if used, would generate significant gain (Alavi and Henderson 1981; Nickerson 1981; Swanson 1988). Understanding why people accept or reject information technology is the first step toward the solution of the problem. Viewing IT acceptance and usage as a user behaviour enabled IS researchers to assimilate some models from social psychology in order to predict the determinants of user acceptance of IT.

The technology acceptance model (TAM), was first introduced by Davis in 1986. TAM is an adaptation of the theory of reasoned actions (TRA) from social psychology which is concerned with the determinants of consciously intended behaviours (Ajzen and Fishbein 1980; Fishbein and Ajzen 1975). The goal of TAM is to provide an explanation of the determinants of computer acceptance that is general, capable of explaining user behaviour across a broad range of end-user computing technologies and user population (Davis et al 1989). Igbaria (1993) and Davis (1993) used TAM for empirically testing user acceptance of microcomputers, and electronic mail and a text editor respectively.

Another social psychology theory is used by Thompson, Higgins, and Howell (1991) who predicted a model of utilization for personal computing using the work of Triandis (1977; 1980) as a theoretical grounding for their research. In their study, they tested a subset of Triandis' (1980) theory applied to the context of PCs use. Triandis (1980) has proposed his theory that incorporates many of the same concepts and constructs of TRA but also modifies and redefines them (Thompson et al 1991).

TRA channels all beliefs that a person has about an act or behaviour through either subjective norms (SN) or attitude (A) and A and SN are jointly affecting behaviour intention (BI) toward behaviour. Triandis' model, however, makes a distinction between beliefs that link emotions to the act and beliefs that link the act to future consequences. In other words, this latter model theorizes that beliefs, A, and social factors (i.e., SN) run in parallel toward behaviour via BI, while TRA makes all beliefs work through subjective norms (SN) or attitude (A) toward behaviour via BI as depicted in Figure 3.1 in Chapter 3.

TRA asserts that factors that influence behaviour do so only through A and SN. In utilizing this assertion in the context of IS, TRA mediates the impact of external variables on user acceptance of IT. As Davis et al (1989) put it "TRA captures the internal psychological variables through which numerous *external* variables studied in IS research achieve their influence on user acceptance, and may provide a common frame of reference within which to integrate various disparate lines of inquiry" (p. 984-985).

Besides that, TRA has been widely used in applied research settings spanning a variety of subject areas (Davis et al 1989) and a substantial body of empirical data in support of TRA has been accumulated (Ajzen and Fishbein 1980; Fishbein and Ajzen 1975).

Moreover, while TRA has been adopted recently by IS researchers (Swanson 1982; Davis 1986; Trice and Treacy 1988; Davis et al 1989; Igbaria 1993; Davis 1993), Triandis' (1980) theory has only been used once within the IS context by Thompson et al (1991) and this lead to some caution in it's application to the current study. Triandis' model loses its structural strength and proper causal ordering once BI is dropped (as discussed in the next chapter) whilst TRA manages to retain these useful characteristics. Thus, for these reasons, TRA is preferred over Triandis' model and chosen here as a theoretical grounding for this study.

Davis et al (1989) recommend that future research in this direction should yield practical techniques to evaluate and improve end-user systems. Following their recommendation, this study is using TRA as a base theoretical grounding and using TAM with extensions that are deemed necessary for incorporating more IT characteristics and external variables. Information technology characteristics which pave the way to measures of user acceptance of IT are discussed next.

INFORMATION TECHNOLOGY CHARACTERISTICS

In the literature reviewed, no such specific terminologies were found to match the above title, rather, the term "innovation" is matched here with "information technology" which is spreadsheet software in this study. Another term which coexists with innovation is "adoption" which is matched here with "acceptance". This is a necessary introduction to this sub-heading from which a clear and strong link is established between this study and the literature reviewed.

Innovation characteristics research describes the relationship between the attributes or characteristics of an innovation and the adoption and implementation of that innovation (Tornatzky and Klein 1982; Rogers 1983). In determining what characteristics to examine in this research, the researcher relied primarily on the extensive work of Tornatzky and Klein (1982), Rogers (1983), Davis (1989), and Moore and Benbasat (1991).

Recently, researchers in IS have begun to rely on the theories of innovation diffusion to study implementation problems (Zmud 1982; Brancheau and Wetherbe 1990; Moore and Benbasat 1991). A major focus in these studies has been how potential users' *perceptions* of the information technology innovation influence its adoption (Moore and Benbasat 1991).

Tornatzky and Klein (1982) in a review and meta-analysis of seventy-five articles concerned with innovation characteristics and their relationship to innovation adoption and implementation, found three innovation characteristics (1) ***compatibility*** (2) ***relative advantage*** (3) ***complexity***, had the most consistent significant relationships to innovation adoption. They found that ***compatibility*** and ***relative advantage*** were both positively related to adoption while ***complexity*** was negatively related to adoption.

One of the most often cited reviews of the perceived characteristics literature is that of Rogers (1983), who, in a survey of several thousand innovation studies, identified five characteristics of innovation which affect the rate of diffusion of an innovation. They are ***relative advantage***, ***complexity***, ***compatibility***, ***observability***, and ***trialability***. Rogers defined them as follows:

Relative advantage: the degree to which an innovation is perceived as being better than its precursor;

Complexity: the degree to which an innovation is perceived as being difficult to use;

Compatibility: the degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters;

Observability: the degree to which the results of an innovation are observable to others; and

Trialability: the degree to which an innovation may be experimented with before adoption.

Moore and Benbasat (1991) identified two further constructs beyond Rogers' classification which were thought important in the decision to adopt an innovation. The first was ***image***, defined as "the degree to which use of an innovation is perceived to enhance one's image or status in one's social system". The second was ***voluntariness*** of use, defined as "the degree to which use of the innovation is perceived as being voluntary or of free will".

Nevertheless, Rogers (1983) also argues that "undoubtedly one of the most important motivations for almost any individual to adopt an innovation is the desire to gain social status" (p. 215). Furthermore, as discussed by Tornatzky and Klein (1982), some researchers have found the effect of social approval (***Image***) to be different enough from ***Relative Advantage*** to be considered a separate factor.

Davis (1986) developed a Technology Acceptance Model (TAM), which was quite similar to a Diffusion of Innovations model. Davis included two constructs, ***perceived usefulness*** and ***perceived ease of use***, which he defined (Davis 1989) as follows:

perceived usefulness: the degree to which an individual believes that using a particular system would enhance his or her job performance.

perceived ease of use : the degree to which an individual believes that using a particular system would be free from physical and mental efforts.

The similarities between these constructs and Rogers' perceived Relative Advantage and perceived Complexity are clear. Usefulness and ease of use are both believed to be important factors in determining acceptance and use of information systems (Lu and Gustafson 1994; Igbaria 1993; Keil et al 1995).

Davis et al (1992) in their study of "Extrinsic and Intrinsic Motivation to Use Computers in the Workplace" argued that extrinsic motivation influences behaviour due to the reinforcement value of outcomes (e.g., perceived usefulness), intrinsic motivation refers to the performance of an activity for no apparent reinforcement other than the process of performing the activity per se (e.g., enjoyment).

Enjoyment was studied by Thompson et al (1991) as a construct under the term of "affect" and by Igbria et al (1994) under the name of "perceived fun". Stewart (1994) stressed the importance of enjoyment in saying "we greatly undervalue the role of enjoyment, fun and playful behaviour in business".

Based on that, enjoyment is examined as an important characteristic of information technology acceptance in this study. Enjoyment is defined by Davis et al (1992) as follows:

Enjoyment: the extent to which the activity of using the computer (IT) is perceived to be enjoyable in it's own right, apart from any performance consequences that may be anticipated.

Regarding the choice of the term ***Relative Advantage*** over ***Perceived Usefulness,*** the term "perceived usefulness" may be confounded with what it was first used for to describe the attributes of information in the design of information systems; and even though Davis (1989) does not use the term "relative" in his label, the definition of "perceived usefulness" is in relative terms. On the other hand, "innovations are typically developed with certain purposes in mind, and they must be perceived to fulfill their intended purposes better than their precursors if they are to be adopted" (Moore and Benbasat 1991). Thus the term ***Relative Advantage*** has a significant intuitive appeal as it is a more general concept and it was decided to retain it for this study.

Also, the choice of using the term ***Perceived Ease of Use*** over ***Complexity***, was made because "complexity" enquires about a negative perception of an innovation, wheras, the term "perceived ease of use" reveals a positive perception. All other terms were positive in connotation. Over all, the literature gave nothing in support of either term. Therefore, the term ***Perceived Ease of Use*** has an intuitive appeal and it was decided to retain it for this study.

Observability and trialability are both dropped from the scope of this study because spreadsheets are clearly observable and trailable as a result of the proliferation and prevalence of spreadsheets discussed earlier. More over, neither of them were mentioned as being of those characteristics having the most significant relationships to innovation adoption (Tornatzky and Klein 1982). Thus, the information technology characteristics to be examined in this study are the six characteristics:

1. Relative advantage
2. Ease of use
3. Compatibility
4. Enjoyment
5. Image
6. Voluntariness

MEASURES OF USER ACCEPTANCE OF IT

Management is naturally eager to determine how well a given system performs in order to assess the degree to which investment in IT can be shown to have been worthwhile, to take action if improvement is needed, and to learn from past experience for future investment decisions (Eilon 1993). Numerous investigators have wrestled with this knotty subject applying several indicators of the success of end-user computing is found in the MIS literature. These include user satisfaction (Ives et al 1983; Bailey and Pearson 1983; Cheney et al 1986; Rivard and Huff 1988; Doll and Torkzadeh 1988), system utilization (Srinivasan 1985; Lee 1986; Igbaria et al 1989; Davis et al 1989; Igbaria et al 1990; Thompson et al 1991; Davis 1993; Igbaria 1993), system quality (Rivard and Huff 1985; Rivard et al 1991; Amoroso and Cheney 1992), and system performance (Lucas 1975; Ein-Dor and Segev 1982).

User acceptance is often the critical factor determining the success or failure of information technology (Davis et al 1989; Igbaria 1990; Thompson et al 1991; Davis 1993; Igbaria 1993; Torkzadeh and Dwyer 1994). When a good user acceptance of information technology is attained and the objectives are achieved, the IT product is widely used and is therefore regarded as successful (Igbaria 1990).

How, then, is user acceptance to be measured? One suggestion is to use surrogate measures as reflective dimensions of user acceptance, one of the most common surrogate measures being user information satisfaction (UIS) (Ives et al 1983; Bailey and Pearson 1983; Cheney et al 1986; Raymond 1987; Rivard and Huff 1988; Doll and Torkzadeh 1988; Igbaria et al 1990; Melone 1990). A second suggestion is to use utilization measures using self-reported measures to operationalize system use and acceptance (Srinivasan 1985; Lee 1986; Davis et al 1989; Igbaria et al 1989; Igbaria et al 1990; Thompson et al 1991; Davis 1993; Igbaria 1993).

The main difference between the two methods proposed for measuring user acceptance of IT is that, UIS is measuring the subjective value of the product while the other is attempting to measure an objective value which is a function of its specification in relation to competing products (Eilon 1993). However, user satisfaction and system usage have rarely been included in the same study or measured simultaneously within a single sample (Baroudi et al 1986; Rivard and Huff 1984; Srinivasan 1985; Igbaria 1990). Accordingly, a primary issue which emerges for this study is the investigation of both usage and user satisfaction simultaneously as dual measures of user acceptance of spreadsheets.

User Information Satisfaction

Bailey and Pearson (1983) defined user information satisfaction (UIS) as *a multidimensional attitude of the user toward different aspects of an information system.* Ives et al (1983) and Iivari (1987) described UIS as the perceived effectiveness of an information system. Ives et al (1983) defined UIS as *the extent to which users believe the information system available to them meets their information requirements.* They mentioned that the concept of UIS can be traced back to the work of Cyert and March in 1963, who suggest that an information system which meets the needs of its users will reinforce satisfaction with that system.

Employing user information satisfaction in the evaluation of IS effectiveness is certainly well established in the literature (Melone 1990). UIS provides the most frequently used "surrogate" measure of MIS success (Bailey and Pearson 1983; Ives et al 1983; Cheney, et al 1986; Raymond 1987; Doll and Torkzadeh 1988; Melone 1990; Igbaria et al 1990; Allingham and O'connor 1992). UIS is conceptualised as the end user's attitude toward the computer application he/she uses in the traditional data processing environment.

Although the UIS instrument has gone through refinements, it has not been validated for assessing specific end-user applications and it also ignores important ease of use aspects of man-machine interface (Doll and Torkzadeh 1988). They argued that the nature of the UIS instrument items assume a more traditional computing environment and, like user knowledge, involvement and information product items are not application specific. All of these called for looking for some more appropriate instrument applicable to the nature of an end-user computing environment. The development of end-user computing satisfaction instrument and its differences with UIS is discussed next.

End-User Computing Satisfaction

Researchers, managers, and professionals are required to investigate the ways and methods available to improve management of EUC. Cheney et al. (1986) call for more empirical research on the factors which influence the success of end-user computing. Doll and Torkzadeh (1988) construct the end-user computing satisfaction (EUCS) instrument as a response to this call which provides a good means for measuring the acceptance of end-user computing facilities.

Doll and Torkzadeh (1988) identify the underlying factors or components of EUCS and express how the need for this instrument arose and how it differs from the UIS instrument:

> The growth of EUC is presenting new challenges for information system management. Measures of user information satisfaction developed for a traditional data processing environment may no longer be appropriate for an end-user environment where users directly interact with application software. Indeed, user information satisfaction instruments have not been designed or validated for measuring end-user satisfaction. They focus on general satisfaction rather than on a specific application, and they omit aspects important to end-user computing such as ease of use. Hence, this study distinguishes between user information satisfaction and an end user's satisfaction with a specific application.
>
> (Doll & Torkzadeh 1988 : p 260)

They concluded that EUCS is an instrument that appears to have adequate reliability and validity across a variety of applications. It is short, easy to use, and appropriate for both practical and research purposes. Its component factors are distinct, enabling researchers to develop and test more precise research questions. Doll and Torkzadeh (1988) and Torkzadeh and Doll (1991) argue that EUCS is an important theoretical construct because of its potential for helping us discover both forward and backward links in a causal chain. In their view, EUCS is potentially both a dependent variable (when the focus of the research interest is upstream activities or factors that cause EUCS) or an independent variable (when the domain of one's research interest is downstream behaviours affected by EUCS).

However, some criticism of the EUCS instrument has been raised by Etezadi-Amoli and Farhoomand (1991). This is regarding: (1) methodological concerns about the measurements of EUCS, and (2) the purpose for measuring EUCS or the procedures for developing Likert-type scales. Doll and Torkzadeh (1991) refute the criticism as they identify theoretical issues that guide the instrument development. They explain the purpose of the EUCS instrument in terms of the research domain in which it was designed to be useful, its role in that domain, and also respond to specific methodological concerns.

Torkzadeh and Doll (1991) published a test-retest reliability for the EUCS instrument. Their article examines the stability of individual items and subscales as well as the 12-item instrument. The results suggest that the instrument is internally consistent and stable. The recommendation of Venkatraman and Grant (1986) regarding instrumentation for organizational strategey research were used by Zmud and Boynton (1991) as a set of three "filtering rules" for identifying well-developed MIS survey instruments:

1) that scales use multiple, higher-level items rather than single, nominal items;
2) that scales be internally consistent;
3) that scales be valid.

From 119 scales investigated, EUCS was one of only three scales passed these three filtering rules.

In a repeated test-retest reliability of the EUCS instrument at two points in time, separated by a two year interval, Hendrickson et al (1994) add further support for the reliability of the EUCS measure. A confirmatory factor analysis for EUCS was carried out by Doll et al (1994) which completes one exploratory-confirmatory research cycle by more rigorously validating the EUCS instrument. The results enhance the utility of the EUCS by providing confirmation that it explains and measures the user satisfaction construct and suggest that it can now be used as a standardized measure of user satisfaction with a specific application.

EUCS has been administered by many researchers in a variety of computing platforms -- mainframe or personal computer. To name but few examples of these applications: E-Mail, payroll, accounting, DSSs, word-processing, and spreadsheets. EUCS is a second-order factor model that consists of five first-order factors measured by 12 items:

* Content (4 items)
* Accuracy (2 items)
* Format (2 items)
* Ease of Use (2 items)
* Timeliness (2 items).

The EUCS instrument is more geared to the study of spreadsheets acceptance than a general UIS instrument since the spreadsheet work being considered is always part of end-user computing systems. In addition, EUCS attains adequate reliability and validity as mentioned above. For these reasons, EUCS is used in this study to develop and evaluate the end users' satisfaction construct as an antecedent to system utilization.

System Utilization

Utilization has been studied by a number of researchers in the past two decades (Lucas 1975; Robey and Zeller 1978; Ein-Dor and Segev 1982; Ives and Olson 1984; Srinivasan 1985; Trice and Treacy 1988; Davis et al 1989; Igbaria 1990; Amoroso and Cheney 1992; Torkzadeh and Dwyer 1994). Amoroso and Cheney (1992) explain the reasons why managers are so diligently seeking for a good measure of utilization. One reason involves the need to justify expenditures on IT which end users continue to demand. Another reason is the rapid introduction of emerging technologies in corporations every year. They argue that, unlike UIS, standard utilization measures are still not present today.

Ives et al (1983) described UIS as a perceptual or subjective measure of system success; it serves as a substitute for objective determinants of information system effectiveness which are frequently not available. They argued that system usage (utilization) can be a surrogate indicator of system success under certain conditions: if users consider the system to be unreliable or its data inaccurate, their usage will reflect those doubts; if usage is voluntary, the system will be avoided; if usage is mandatory by management, for political motivation, or for self-protection in justifying "poor" decisions, perceptual measures may be more appropriate in this involuntary situation.

However, Bailey and Pearson (1983) argued that utilization is directly connected to the user community's sense of satisfaction with those services. Further more, Cheney et al (1986) argued that, "We, among others, believe that utilization is highly correlated with the other surrogate measures of MIS and EUC success."

Ives and Olson (1984) in their review of research for twenty two studies in the field of user involvement and MIS success, reviewed system usage besides the other types of user's behaviour or attitudes toward the system. Ives and Olson described system utilization as a useful measure of user acceptance validating the belief that usage by end users describes the application is attaining its development goal.

Srinivasan (1985) defined system utilization as a behavioural measure and states that, "If the user exhibited increased evidence of system use in situations where use was not mandatory (i.e., use is discretionary), then he must find the system useful." Srinivasan reported a negative type of relationship between UIS and utilization, contrary to most previous research findings, in saying "while much of the existing MIS research implies that the two types of measures are positively associated with each other, the results of this study indicate otherwise."

System utilization is often operationalized using self-reported measures of actual system usage as a measure of user acceptance of the system. Five indicators were found and used in several studies on MIS usage (Srinivasan 1985; Lee 1986; Igbaria et al 1989; Davis et al 1989; Thompson et al 1991; Davis 1993; Igbaria 1993); (1) time spent on using the system per day; (2) frequency of system use; (3) the number of software packages used by the participants; (4) the number of applications for which the system is used; and (5) level of sophistication of usage.

From the above review it seems that employing system utilization as a measure of user acceptance of IT is a well established direction in the literature. In conclusion, as far as the measures of user acceptance of IT are concerned, two main directions were found in the literature: (1) measuring user satisfaction about IT (2) measuring IT utilization. Both directions are employed in this study.

SUMMARY

IT is spreading in organisations very rapidly and EUC will soon dominate most MIS departments. The flood of microcomputers fuelled by spreadsheet packages constitute powerful tools enabling end users to create their own applications. This calls for studying the phenomena and trying to investigate the factors contributing to spreadsheets acceptance as the first step toward better control and management.

The previously reviewed MIS studies on IT acceptance have investigated the acceptance of general products of IT, mainly microcomputer technology and word-processing or communications software. None of the IT acceptance studies attempted to investigate the factors contributing to the acceptance of spreadsheets as an important IT product proliferating in modern organisations.

Assimilating a model for IT acceptance with a model from social psychology behaviour enabled IS researchers to investigate its antecedents. TAM which is based on TRA is employed in this study with further extensions. The research on information technology acceptance provided evidence that users tend to accept or reject an IT because of its characteristics. The user's perceptions and beliefs about an IT characteristics correspond to the beliefs perceived about an object in the social psychology model. Six characteristics about spreadsheets which are thought to enforce user acceptance are investigated in this study.

Researchers are striving to find good instruments to measure user acceptance of IT. Two main directions were found in the literature: (1) measuring user satisfaction about IT (2) measuring IT utilization. EUCS is geared to EUC rather than the more general UIS. Both EUCS and utilization are employed in this study.

Chapter 3

RESEARCH FRAMEWORK

The literature review in the previous chapter identified a model which linked IT acceptance to IT characteristics which are in turn linked to external variables. The review located a comprehensive model borrowed from social psychology as a theoretical grounding for IT acceptance. The research framework draws heavily on the theory of reasoned action (TRA) and the technology acceptance model (TAM). This chapter discusses how TRA and TAM were adapted to provide the research framework for the study. The chapter then goes on to discuss the major variables, and to state the research hypotheses to be investigated.

Theory of Reasoned Actions

The theory of reasoned action (TRA) is a widely studied model from social psychology which is concerned with the determinants of consciously intended behaviours (Ajzen and Fishbein 1980; Fishbein and Ajzen 1975). The foundation of the TRA conceptual framework is provided by the distinction between beliefs, attitudes, intentions, and behaviours. The major concern of the conceptual framework, however, is with the relations between these variables, as depicted in Figure 3.1.

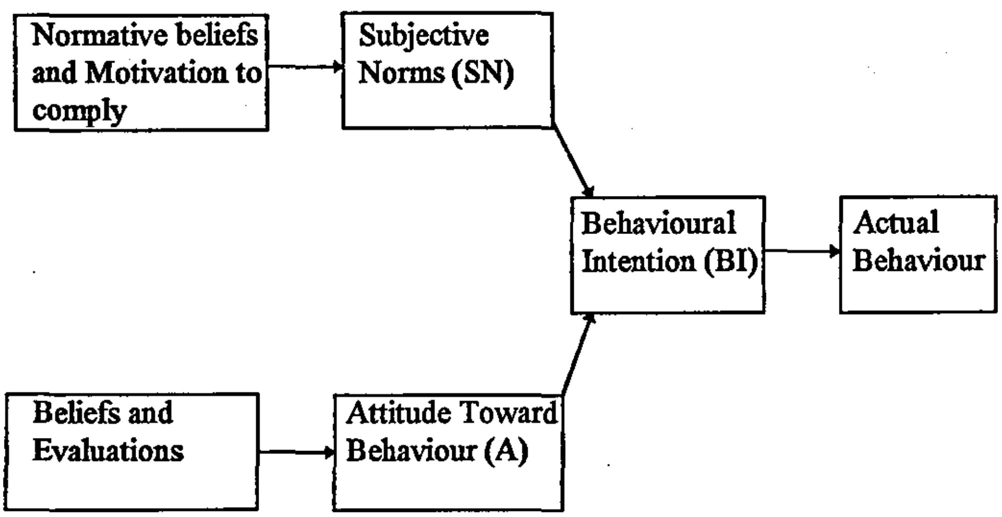

Figure 3.1 Theory of Reasoned Action (TRA)

According to TRA, a person's performance of a specified behaviour is determined by his or her behavioural intention (BI) to perform the behaviour, and BI is jointly determined by the person's attitude (A) and subjective norms (SN) concerning the behaviour in question.

BI is a measure of the strength of one's intention to perform a specific behaviour (Fishbein and Ajzen 1975, p. 288). ***A*** is defined as an individual's positive or negative feelings (evaluative affect) about performing the target behaviour (Fishbein and Ajzen 1975, p.216). ***SN*** refers to "the person's perception that most people who are important to him think he should or should not perform the behaviour in question" (Fishbein and Ajzen 1975, p. 302).

According to TRA, a person's attitude toward a behaviour is determined by the sum of his or her salient belief (b_i) about the consequence *i* of performing the behaviour multiplied by the evaluation (e_i) of that consequence:

$$A = \Sigma\, b_i\, e_i$$

Belief (b_i) is defined as the individual's subjective probability that performing the target behaviour will result in consequence *i*. The evaluation term (e_i) refers to "an implicit evaluative response" to the consequence (Fishbein and Ajzen 1975, p.29). The equation of A above represents an information-processing view of attitude formation and change which posits that external stimuli influence attitudes only indirectly through changes in the person's beliefs structure (Ajzen and Fishbein 1980; Davis et al 1989).

An individual's subjective norms (SN) is determined by a multiplicative function of his or her normative beliefs (nb_i), i.e., perceived expectations of specific referent individuals or groups, and his or her motivation to comply (mc_i) with these expectations (Fishbein and Ajzen 1975, p. 302):

$$SN = \Sigma\, nb_i\, mc_i$$

TRA is a general model as it does not specify the beliefs that are operative for a particular behaviour. Therefore, researchers using TRA must first identify the beliefs that are salient for subjects regarding the behaviour under investigation (Davis et al 1989). Fishbein and Ajzen (1975, p. 218) and Ajzen and Fishbein (1980, p. 68) suggest eliciting five to nine salient beliefs using free response interviews with representative members of the subject population. The beliefs identified for this study are discussed after the next section.

A particular helpful aspect of TRA from an IS perspective is its assertion that any other factors that influence behaviour do so only indirectly by influencing A, SN, or their relative weights (Davis et al 1989). Thus, variables such as system design characteristics, user characteristics, task characteristics, development or implementation process, organisational structure would fall into this category, which Fishbein and Ajzen (1975) refer to as "external variables".

Based on that, Davis et al (1989) state "this implies that TRA mediates the impact of uncontrollable environmental variables and controllable interventions on user behavior. If so, then TRA captures the internal psychological variables through which numerous *external* variables studied in IS research achieve their influence on user acceptance, and may provide a common frame of reference within which to integrate various disparate lines of inquiry" (p. 984-985).

Technology Acceptance Model

The Technology Acceptance Model (TAM) was first introduced by Davis (1986). TAM is an adaptation of TRA specifically tailored for modelling user acceptance of information technology. "The goal of TAM is to provide an explanation of the determinants of computer acceptance that is general, capable of explaining user behaviour across a broad range of end-user computing technologies and user populations" (Davis et al 1989, p. 985).

A key purpose of TAM, therefore, is to provide a basis for tracing the impact of external factors on internal beliefs, attitudes, and intentions. TAM was formulated in an attempt to achieve these goals by identifying a small number of fundamental variables suggested by previous research dealing with cognitive and affective determinants of computer acceptance. However, TRA is still used as the theoretical background for modelling relationships among these variables in the TAM model.

TAM postulates that two particular beliefs, *perceived usefulness* and *perceived ease of use*, are of primary relevance for computer acceptance behaviours, as depicted in Figure 3.2. Similar to TRA, TAM postulates that computer usage is determined by BI, but differs in that BI is viewed as being jointly determined by the person's attitude toward using the system (A) and perceived usefulness. According to TAM, attitude toward using the system (A) is jointly determined by usefulness and ease of use.

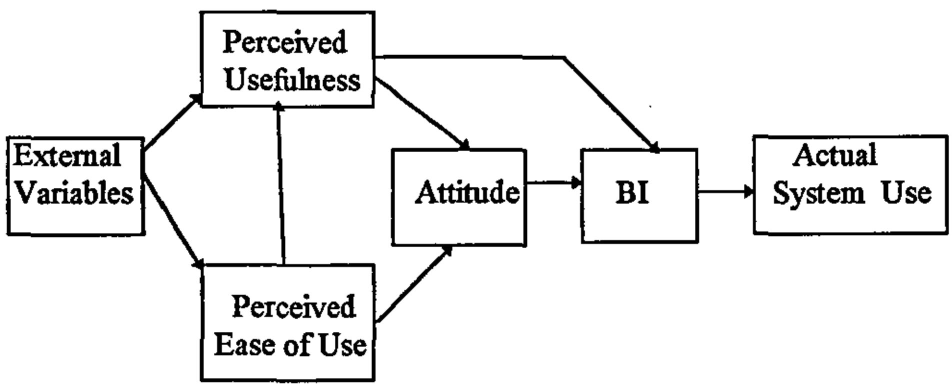

Figure 3.2 Technology Acceptance Model (TAM)

TAM posits that although perceived usefulness has an indirect impact on BI through its direct positive influence on A, it also has a direct effect on BI. Perceived ease of use is also postulated to have a significant effect on A. As TAM implies, perceived usefulness can be affected by various external variables but also can be affected by perceived ease of use. Whereas, perceived ease of use is theorized to be determined solely by external variables.

To give a definition for attitude (A) within the context of TAM, Fishbein and Ajzen (1975, p. 31) draw the distinction between two attitude constructs: attitude toward the object (A_O), which refers to a person's affective evaluation of a specified attitude object, and attitude toward the behaviour (A_B), which refers to a person's evaluation of a specified behaviour involving the object. Ajzen and Fishbein (1977) have shown that A_B relates more strongly to a specified behaviour than does A_O. TAM employed attitude toward using the system, adopting the general A_B definition as: *the degree of evaluative affect that an individual associates with using the target system in his or her job* (Davis 1993).

TAM does not include TRA's subjective norms (SN) as a determinant of BI. Davis et al (1989) reported the acknowledgment of Fishbein and Ajzen (1975, p. 304) that SN is one of the least understood aspects of TRA. Davis et al (1989) justify their decision in not including SN in TAM by stating that "because of its uncertain theoretical and psychometric status, SN was not included in TAM".

Extending The Model of TAM

Following Thompson et al (1991) and Davis (1993), it was deemed necessary to drop BI and link A_B and SN to actual behaviour directly. Thompson et al (1991) argue that BI should be excluded because we are interested in actual behaviour (system usage). Such behaviour has already taken place in the past, while BI is "the person's subjective probability that he will perform the behavior in question" (Fishbein and Ajzen 1975, p. 12) and is thus dealing with future behaviour. Since this research is concerned with acceptance which has already taken place, it was considered appropriate to follow Thompson et al.

In this study, the research scope is to test a subset of TRA applied to the context of spreadsheet usage. Specifically, the direct effect of attitude (A_B) and subjective norms (SN) on behaviour (which is actual usage) is examined, whilst behavioural intentions (BI) are excluded from the model.

TAM does not include SN and normative beliefs and motivation to comply (NBMC) in its basic model. In addition, it only included two beliefs, perceived usefulness (USEF) and perceived ease of use (EOU). Besides SN and NBMC, this study model will incorporate USEF, EOU, and other beliefs as Davis et al (1989, p. 985) reported that "several studies have found variables similar to these to be linked to attitudes and usage". These beliefs variables will be discussed in detail in the next section.

In addition, TAM adapted the generic TRA model to the particular domain of user acceptance of microcomputer technology, replacing the TRA's attitudinal determinants derived separately for each behaviour, with a set of two variables (i.e., perceived usefulness and perceived ease of use) employed in many computer technology acceptance contexts (Igbaria 1993). Although TAM provided insights into the user acceptance of computer technology, it only focused on these two determinants of usage rather than on the external factors affecting these determinants.

More specifically, the research model used in this thesis applies the causal relationships between all the constructs proposed by the TRA model except BI. At the same time, the model applies a subset of TAM as it identified two particular beliefs and the type of behaviour under investigation which is actual system use. Furthermore, it incorporates several IT characteristics and the TRA's normative beliefs and motivation to comply, as belief variables. Finally, following Davis (1993), and Igbaria (1990, 1993) the study's model will investigate several proposed external variables, as antecedents to the belief variables, which were not explicitly identified by TAM. The research study's model, variables, and hypotheses are discussed in the following section.

Research Variables

The literature review in the previous chapter identified a comprehensive model borrowed from social psychology which linked IT acceptance to IT characteristics which are in turn linked to external variables. The general model in figure 3.3 emerged from adapting a combination of both TRA and TAM.

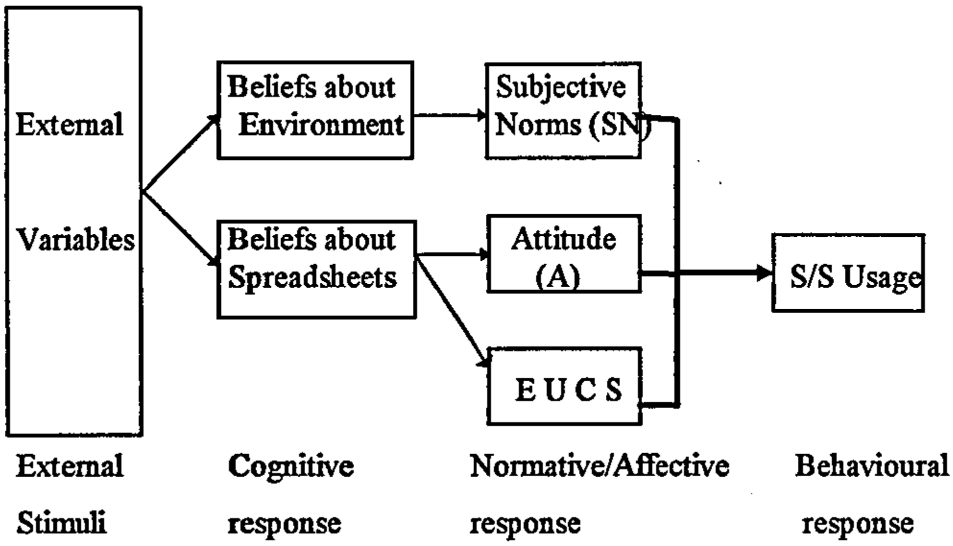

Figure 3.3 The General Research Study's Model

Belief variables are the six IT characteristics identified in the literature review (chapter 2) plus normative beliefs and motivation to comply. These beliefs are divided into two main categories: beliefs about the work environment and beliefs about the system under investigation: spreadsheets (S/S). Beliefs about spreadsheet systems affect attitude toward using spreadsheets and consist of: (1) ***Compatibility*** (2) ***Relative advantage*** (3) ***Ease of use***, and (4) ***Enjoyment.*** Beliefs about the work environment affect subjective norms in the workplace and consist of: (1) ***Normative beliefs and motivation to comply (NBMC)*** (2) ***Voluntariness***, and (3) ***Image.***

Attitude (A) and subjective norms (SN) are the two variables through which belief variables affect the main focus variable in this study: S/S usage. The secondary focus variable (EUCS) is hypothesized to be parallel to A and an antecedent to S/S usage as Baroudi et al (1986) provided some evidence that "the user's satisfaction with the system may lead to system usage".

TAM suggests that belief variables are determined by external variables but does not delineate them. Following Igbaria (1993) and Davis (1993) a set of external variables are incorporated in the research study's model. Davis (1993) used system design features as the only external variable and this concept is incorporated in the present research by employing user's rating of spreadsheets. Igbaria (1993) used demographic variables, user training, computer experience, IC support, and management support. This study employs all Igbaria's external variables after combining both types of support as one variable: EUC support.

Therefore, the set of external variables used in this research consist of end-user background variables, demographic variables, and a spreadsheet system rating variable. End-user background variables comprise end-user training, EUC experience, and EUC support. Demographic variables are the end-user gender and the type of course he or she is studying on.

Based on TRA and TAM the research model was built as depicted in Figure 3.4 below. The research variables consist of the following eight major groups of variables:

1) Behavioural variables = spreadsheets usage.
2) Normative/Affective variables = subjective norms (SN), attitude (A) and end-user computing satisfaction (EUCS).
3) Beliefs about S/S = compatibility, relative advantage, ease of use, and enjoyment.
4) Beliefs about the work environment = normative beliefs and motivation to comply (NBMC), voluntariness, and image.
5) Demographic variables = gender, course.
6) End-user background variables = end-user (training, computer experience, computing support).
7) Spreadsheet system (S/S) rating.
8) External variables = (5) + (6) + (7).

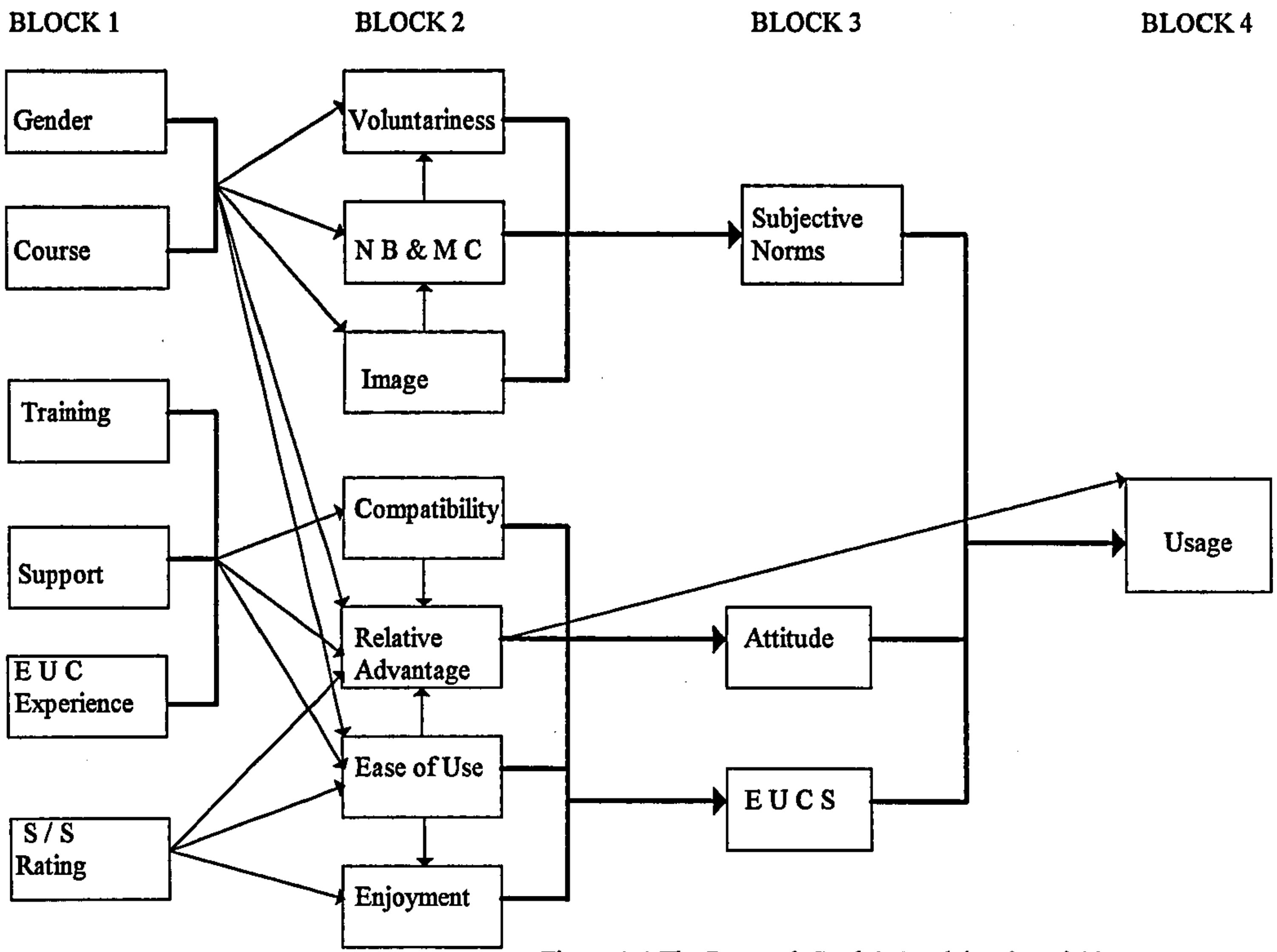

Figure 3.4 The Research Study's Model and Variables

The research model appears to be a 3-stage model which consists of four main blocks of variables. The causal ordering of the research variables are laid down as per Figure 3.4. Apart of the external variables, causal ordering of the major group of variables are employed following TRA. TAM is explored here after dropping BI and linking its two particular belief variables to external variables and linking Relative Advantage to Usage following Davis (1993). Other links between the research variables are either from prior research (Thompson et al 1991, Davis et al 1989, Davis et al 1992, Davis 1993, Igbaria 1990 and 1993) or newly posited for this present research. All in all, the hypothesized linkages between the research variables are portrayed as per the study's model in Figure 3.4 above.

Research Hypotheses

There are a large number of individual research hypotheses which can be derived from the research model just described. A set of ten main hypotheses emerged to be the major research hypotheses, these are stated as follow:

H1: Attitude towards using S/S will mediate the relationships between beliefs about S/S and S/S usage.

H2: Subjective norms will mediate the relationships between beliefs about the work environment and S/S usage.

H3: Each of compatibility, relative advantage, ease of use, and enjoyment will have a significant effect on attitude towards using S/S.

H4: Each of normative beliefs, voluntariness, and image will have a significant effect on subjective norms.

H5: End-user background variables will have significant effects on compatibility, relative advantage, and ease of use.

H6: S/S rating will have significant effects on relative advantage, ease of use, and enjoyment.

H7: Demographic variables will have significant effects on beliefs about the work environment.

H8: Demographic variables will have significant effects on relative advantage, and ease of use.

H9: Each of compatibility, relative advantage, ease of use, and enjoyment will have a significant effect on EUC Satisfaction (EUCS).

H10: EUCS will mediate the relationship between beliefs about S/S and S/S usage.

Summary

Theory of reasoned actions (TRA) is adopted to provide the research framework of this study. TAM which was built on TRA is partially applied and further extended here. Based on that, the research model is built, research variables are identified and causally linked, and research hypotheses are derived.

Ten main hypotheses have been derived linking the research variables employing TRA and extended TAM. The major hypotheses linking external variables, IT characteristics, attitude, and subjective norms with S/S usage are the focus for many of the remaining chapters in this thesis. However, all research hypotheses were considered in the research design, which is the subject of the next chapter.

Chapter 4

RESEARCH DESIGN

The previous chapter stated the ten hypotheses that the research aimed to investigate. The research design is the focus of this chapter. Various approaches are reviewed, with the survey self-administered questionnaire method selected as the vehicle for data collection. The chapter then discusses the important aspects of the survey, including a definition of the population, the determination of a sampling frame and the administration of a survey self-administered questionnaire.

RESEARCH STRATEGIES

Several research strategies in use in information systems (IS) research are found in the literature. Galliers (1985) identified a list of eight major research strategies currently being undertaken in the IS field. The list was updated by Galliers (1992) to be:

- Action research
- Simulation
- Phenomenological studies
- Forecasting / Future research
- Surveys
- Case studies
- Laboratory experiments
- Field experiments.

Longitudinal studies which appeared in the original list were removed as they were considered to be a special case of other types of research and simulation was added to this updated list of 1992. As this study aimed to provide empirical data from natural settings, the future and experimental strategies were deemed inappropriate.

Apart from that of surveys, the other strategies are typically practical for only a small number of organisations. The main advantage to be gained from these typically intensive approaches is that they can provide rich data about underlying processes. They are good at identifying new variables and possible relationships. As a result, these strategies have been found to be very useful for theory building. Their utility in theory testing is questionable, as their limited sample sizes restricts the possibility of generalising for the findings.

The research study hoped to investigate the relative impact of factors contributing to spreadsheets acceptance across several organisations with different types of end users. Davis et al (1989), Thompson et al (1991), Igbaria (1993), and Davis (1993) attempted something similar when investigating the acceptance of IT. Their experience indicated a sample size more than 100 would be needed if statistical analysis was to be conducted satisfactorily with control variables.

A clear advantage of the survey approach was that it had been proven by the above mentioned works as an effective method for the collection of data on IT acceptance. Many researchers in MIS have encountered the problem of anonymity with respondents who tended to have limited disclosure of their negative attitudes toward IT (e.g., Torkzadeh and Angulo 1992). As the research model (Chapter 3) is dealing with both organisational and technological environments, the survey approach is considered the most appropriate.

With the survey method it is theoretically possible to collect data from a large number of individuals in a wide range of organisations. Thus allowing quantitative analysis in the testing of hypotheses and also the potential to generalise the findings to similar types of end users in different types of organisations.

One of the major disadvantages of the survey approach was that the important variables had to be known in advance. Thus it is best suited for use in relatively well understood situations. In fact, as was shown in previous chapters, there is a relatively large literature in the area of IT diffusion which has discussed factors contributing to end-user's satisfaction and usage of IT. Hence it was possible to define and isolate the important variables in this study of spreadsheets acceptance, as already described.

The survey approach was seen to be powerful with respect to quantifying relationships between variables, but weak at providing insight about cases. However, providing insight about cases is beyond the scope of this research as it is clear from the research framework in the previous chapter.

The remainder of this chapter discusses the survey design, including the survey method used, the population under study, and the administration of the questionnaire.

SURVEY METHOD

The survey method was selected to obtain data from a large number of end users. Teng and Galletta (1991) in viewing MIS research directions found that more than half of MIS researchers employ the survey method. However, a questionnaire based survey can be conducted in different ways. The relative strengths and weaknesses of these approaches are discussed subsequently, before reviewing the methods in light of the research objectives.

Three Questionnaire Approaches

Dillman (1978) considered three different ways: in face to face interviews, by telephone, or by mail. Based on many years of experience with large surveys, he provided a comprehensive comparison of the three approaches, with 24 factors being seen as important when evaluating the merits of the three methods. As with all research strategies, no one approach always scores highly positive for all situations.

Dillman concluded that each method has merits as well as shortcomings, and the choice is very much dependent on the research objectives. The major strengths and weaknesses of the three methods are summarized below in Table 4.1:

Table 4.1: The major strengths and weaknesses of the three survey methods

Method / Feature	Mail Survey	By Telephone	Fact-to-Face Interview
fixed cost	high	medium	low
marginal cost	low	medium	high
explanation	low	high	high
response rate	low	high	high
completion time	short/long	short	very long
inherent bias	free	bias	bias
anonymity	high	low	low

From table 4.1 and in view of this research objectives, the mail questionnaire approach was considered as the most appropriate data collection method. However, in certain conditions, more participation from the researcher may be preferred over the straight-forward mail questionnaire. According to the study sampling frame and method of access (discussed next), a modified version of the self-administered questionnaire method was chosen and employed for this study.

The essential aspect of a self-administered questionnaire is that the respondent independently reads the written questions and then makes a written response (in a variety of possible forms) usually on the same sheet of paper as the questions. When the question paper is received through the post and the responses returned by post this is a straightforward mail questionnaire. However, there are other possible ways of delivering the questionnaire and collecting the responses.

The self-administered questionnaire approach was considered the most likely of the above mentioned methods to obtain data about end-users' beliefs related to spreadsheets and normative beliefs and motivation to comply with these beliefs.

This is so because, the subjects are relatively bias-free in expressing their views regarding their beliefs, attitudes toward spreadsheets, and norms in the workplace and their motivations toward it.

Babbie (1973) emphasized that, "while the mail survey is the typical form of self-administered study, there are several additional methods in this regard. In some cases, it may be appropriate to administer the questionnaire to a group of respondents gathering at the same place at the same time". Babbie concluded that, the appearance of a research worker, either delivering the questionnaire, picking it up, or both, seems to produce higher completion rate and reducing costs than the straightforward mail surveys.

There are number of other advantages in having a questionnaire, completed in the presence of the researcher, rather than the conventional mail survey approach. Within the context of the questionnaire, the presence of the researcher generally decreases the number of *don't knows* and *no answers* (Babbie 1973). In addition, explanation can also be provided if the respondent is confused about the questions. As the research administrator is present he or she can clarify matters, thereby obtaining more relevant responses. This approach was chosen for the present research and the method which involved the researcher being present when the questionnaire was issued to a group of respondents will be referred to as the "supported" questionnaire method.

Many IS researchers have utilised students as surrogates for general employees. Ein-Dor and Segev (1982) utilised graduate students who were assigned individual projects guided by a questionnaire which is finally to be endorsed by the relevant MIS director. Davis et al (1989) and Davis (1993) collected data from MBA students. Igbaria et al (1989) and Igbaria et al (1990) used employed MBA students. Galletta (1993) approached undergraduate students in classroom sessions for data collection. Carlsson (1988) collected data from trainees on spreadsheets training courses.

Students who have been in industry for one year sandwich training and used spreadsheets were chosen as the sample from which to collect the research data applying the "supported" questionnaire method. Also, it was decided to approach students in normal classroom sessions at the beginning of the first term following their one year training in industry rather than mailing questionnaires to them while training takes place. This decision was taken primarily on practical grounds as this method seemed most likely to provide a large sample of end users and a higher completion rate at both reasonable cost and within a reasonable time frame.

It was appreciated that the chosen survey method could be considered to have a disadvantage in that there might be difficulty in fully accepting students as genuine representatives for employees in organisations. In fact, there are several opinions found in the literature regarding this issue. Two basic and direct studies (Latour et al 1990 and Barrier and Davis 1993) are reviewed here discussing the possibility and extent of supporting our choice.

Latour et al (1990), in their article "Are Students a Viable Source of Data for Conducting Survey Research on Organizations and Their Environment?", found the emergence of some experience based differences in perceptions. After reviewing a long debate about this issue, they concluded that "We would argue that the question of whether or not to use students in survey research in lieu of actual members of the population being studied has by no means been resolved. Admittedly, students are convenient, if not sometimes the only, source of data. However, whether this data will provide solutions to or even a greater understanding of problems faced by organizations remains an open question. Ultimately, those researchers who use students as a primary data source need to consider the problem being studied and determine in advance whether these samples are appropriate." (Latour et al 1990, p78).

Barrier and Davis (1993) researched a similar question which was "Are Graduate Students Appropriate Research Surrogates for Managers in Evaluating New IS Technology?". They concluded that "the answer to the research question ... is a qualified yes. The results of this study provide relatively strong evidence that it is appropriate to use students as manager surrogates for new IS technology under certain conditions. The classical circumstances suggested in the literature relative to student surrogates were mirrored by this study. *First*, the environment for the study should be controlled. *Second*, the subject samples should be matched on basis of the task to be performed. *Third*, the task should be the same for each sample." (Barrier and Davis 1993, p60).

Nevertheless, the students chosen for this study are non-traditional students as they have spent one year in the work environment. From the students' point of view, they are seeking employment after graduation and they consider the year of training as a prerequisite for employment which offers them more motivation to behave and think as official employees. Also, in many modern organisations the students on the year in industry are given the same training as full time employees since they are required to apply the same skills on the same type of work. In many ways these students have been treated as employees during their year in the work environment. Since the study concerned their behaviour during that year and was administered very soon after their return to the academic environment, these students could be considered as representatives of a junior management group of employees and thus suitable respondents to handle the issues being researched.

Approaching subjects in normal classroom sessions is a practical necessity and might be thought of as a hybrid of interview and mail questionnaire methods. It could be considered to be a method incorporating the positive aspects of both methods in that one obtains a higher level of explanation, as the research administrator is present in front of subjects, while anonymity of individual response is relatively maintained at the same time.

A response rate in excess of 70% was expected. Thus, the problem of potential bias from non-response was considered to be outweighed by the benefits of a larger sample. The questionnaire administrator is present most of the time for explanation and eventually for paying the incentive and collecting completed questionnaires which over all maximizes the response rate.

The Population

A field study of end user computing by Benson (1983) surveyed twenty locations. Eleven locations were manufacturing corporations among the Fortune 1,000. Other locations included three banking and financial organisations, two insurance companies, and one of each of the following: merchandising, mining, transportation, and government operations.

Other studies, for example Rockart and Flannery (1983) surveyed 200 end users from various sectors, also Doll and Torkzadeh (1988) surveyed 618 end users from a variety of firms: a manufacturing firm, two hospitals, a city government office, and a university.

Hence it seems most appropriate to cover multiple sectors rather than to undertake an intensive study of one sector. The population of this study will be end users working in various private and public sectors throughout Britain.

Before discussing the sampling frame of this study it is important to examine some terms and definitions used by other researchers for end users in previous studies. In articulating these definitions a paradigm could be drawn and a specific definition is located for end users as the units of analysis in the present study.

Definitions of End Users

CODASYL End-User Facilities Committee (Lefkovits, 1979) provided a simple categorisation of end users:

1) ***Indirect*** end users that use computers through others

2) ***Intermediate*** end users who call for specific information that they later receive

3) ***Direct*** end users who actually use terminals.

Researchers in end-user computing (EUC) (e.g., McLean 1979; Martin 1982; Rochart and Flannery 1983; Rivard and Huff 1988) confine their end users to the third category of the CODASYL's, that is, individuals who directly interact with computers. Of the three categories of end users above, this category is the only one to fall within the boundaries of EUC as defined in Chapter 2. The following are the criteria applied in some famous studies to define end users as their units of analysis.

McLean (1979) chose a characterisation of end users to be consistent with the framework of end users contained in the CODASYL report. He adopted the following classification scheme:

— DP professionals (DPP)

— DP users (DPU) which is further divided into:

- DP amateurs (DPA)
- Non-DP trained users (NTU).

McLean stated the definition of each type, most simply, to be: DP professional *writes code for use by others.* The DP amateur *writes code for his or her own use,* and the non-DP trained user *uses code written by others.*

Martin (1982) breaks down the "direct" end user category of CODASYL's categorisation into three further categories:

3.a) Non-data processing (non-DP) trained end users who know nothing about programming but use code written by others to perform their own tasks.

3.b) Data processing (DP) amateurs who write code for their own use.

3.c) Data processing professionals who write code for others.

Rockart and Flannery (1983) carried out an extensive study involving 200 end users and 50 information system support staff. They classified end users into six types:

I. *Non-programming* end users who access computer-based data through software provided by others and access usually through a limited menu driven format.

II. *Command level* end users who perform simple inquiries, generate reports for their own use, and are able to specify the information they want through report generators.

III. *End user programmers* who develop their own software which is often used by others.

IV. *Functional support* personnel who are proficient programmers supporting other end users in specific functional areas.

V. *End user computing support* personnel to be found in a formal computer facility such as an information centre. They are knowledgeable in end user languages and develop applications and "support" software.

VI. *DP programmers* who program in end user languages.

Davis and Olson (1985) suggest four concepts which can be used to help categorise end users:

- *Developers* versus *non-developers*: a system developer is someone who builds an information system to be used by others (non-developers).
- *Novices* versus *experts*: a distinction is based on the experience level of the user. This experience has two components: the frequency of use of the particular system and the user's general knowledge of computer system concepts.
- *Frequent* versus *occasional* users: a frequent user becomes more expert than an occasional user and will use the system for routine tasks. The occasional user, much like a novice, probably uses the system on an ad hoc basis.
- *Primary* versus *secondary* users: a novice who is a primary user might, just send memos or notices through an electronic messaging system, for example. In contrast, an expert who is a primary user might use the computer for financial analysis or simulation. Secondary users (e.g., data entry operators) typically enter data into the computer as a major part of their job.

Finally, Rivard and Huff (1988) stipulate certain characteristics for end users to be included in their study of user development of computer-based applications (UDA):

> Individuals who were not DP professionals and who develop computer applications for themselves or others. In most instances the developer also uses the application, although in a minority of cases the developer will turn the application over to another person for use. The individuals in our study fall into the middle three categories in the Rockart-Flannery typology: command-level users, end-user programmers, and functional support personnel.
>
> (Rivard & Huff, 1988 : 553)

Therefore the Rivard-Huff definition of end users is: Individuals who are ***Non-DP professionals*** who develop computer applications in most instances for themselves and in a minority of cases for others. Their group of end users fall into the middle three categories in the Rockart-Flannery typology; these are: (1) ***command-level*** end users (2) ***end-user programmers*** (3) ***functional support*** personnel.

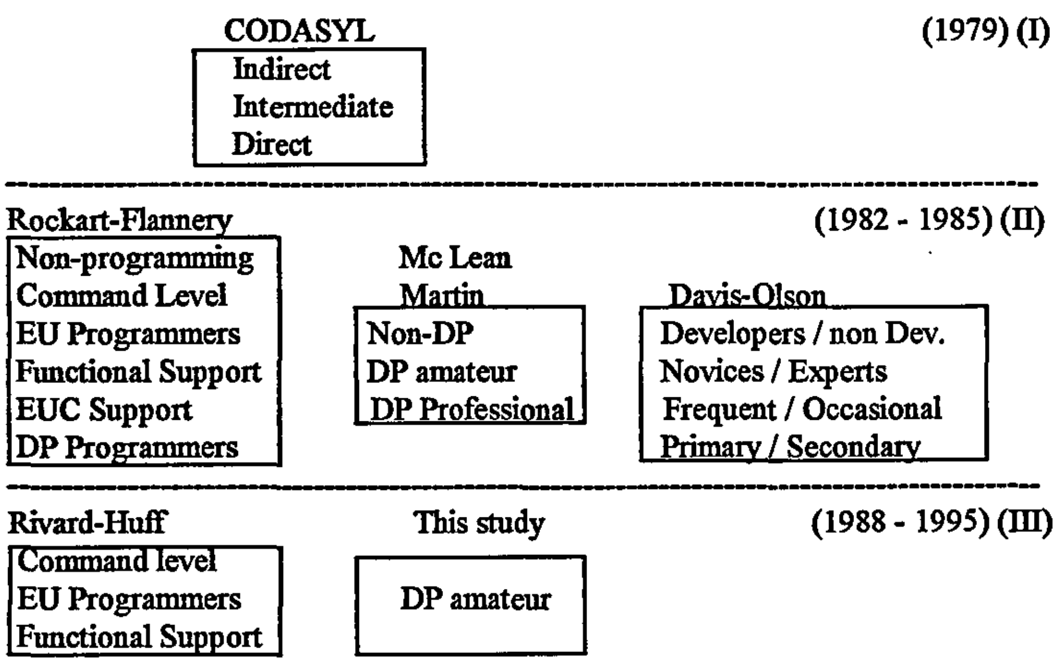

Figure 4.1 End Users Definition Paradigms

As a result, a chronological paradigm could be drawn for these various types of definitions as shown above in Figure 6.1. Following that, each one of these definitions will be discussed from the perspective of this research, in order to derive a final definition for end users of this study.

From the end users definition paradigms (Figure 4.1), one can argue that there exists a paradigm shift as researchers become more selective and definitions become more oriented to certain research areas with time. It can be seen that in stage I, the definition is broad and imprecise. In stage II the definition is more functionally classified and much clearer than before. In stage III the definition becomes more specific as researchers tend to define end users according to some domain and to specific areas of research interest.

CODASYL's definition is too broad as it includes all those who benefit from the computer services (e.g. airline passenger). Their definition could be thought of as the universal set of end users and utilisers of computer services.

The two definitions of McLean and Martin were adapted from the CODASYL's definition. They both drop out the CODASYL's "indirect" and "intermediate" end users and break down three more categories out of the "direct" end users. The centre of their classification scheme seems to be the most relevant and appropriate to this research area. More specifically, DP amateur is the definition of end users which is believed to be the most applicable to this study with some further extension. That is to say: ***Individuals who write code for their own use (which might be used by others occasionally).***

Rockart-Flannery's definition provides a wide span typology which might be more applicable to the mainframe environment, and was published at a time when spreadsheets were probably not yet popular, at least with personal computers. The third category is the most appropriate type of end users to apply to the spreadsheeting area but with some slight modification necessary. That is to say: ***Individuals who develop their own software which might be (instead of "is often") used by others (occasionally).***

Davis-Olson's definition seems to be a multi-criterion concepts which can be used to help categorise end users. With their first criterion (developers vs. non-developers) they limited the function of developers to the development of application systems to be used by others (non-developers) not by themselves. *Developing for self-using* is a major condition and a unique characteristic of the type of end users in this study. That is: ***The person who develops the system should use it.***

Rivard-Huff's definition includes only three categories from the typology of Rockart-Flannery for end users. Two of these categories [(1) and (3)] do not fall under the present research area where spreadsheeting is the computing environment. This is because ***command-level*** end users do not develop any applications as they merely perform simple inquiries and generate reports for their own use, while on the contrary, ***functional support*** personnel are those end users who develop applications not for their own but for other users in their functional areas. We are left with the second category which is to be modified slightly as in the discussion of Rockart-Flannery's definition above.

Review Summary

From the above review of the definitions of end users, it is clear that the definitions given were specified from a certain perspective or were chosen to suit each research area accordingly. It is argued that the existing definitions are not adequate for spreadsheeting purposes where generically the developer is the user. Hence, in trying to establish a definition that best suits the spreadsheeting environment, the focus should be on the type of end users in an environment where both developers and users are the same. This study is concerned with those end users who both develop the spreadsheet application and use it, although it might be used by others on occasion.

The characteristics of end users researched here match the DP amateurs rather than non-DP or DP professionals in reference to *direct* end users. Hence, the above adapted definition completely corresponds to the characteristics of end users involved in the spreadsheeting process, where end users are both developing (or modifying) and using their own spreadsheets which might be used by others occasionally.

End-Users Defined

Thus the definition of end users for the purpose of this study will be as follows:

End Users are: Individuals who both develop (or modify) and use their own spreadsheet applications which might be used by others occasionally.

The definition implicitly includes the end users who are modifying spreadsheets applications developed by others to be used by themselves.

The Sampling Frame

In order to carry out the study it was initially considered desirable to involve a diverse collection of computer end users. Indeed the results would be more generalisable if the research study was targeted to end users from multiple sectors rather than a specific sector.

A sample of 300 to 400 computer end users was expected to be adequate for the study. As the use of spreadsheet packages has moved well beyond accounting (King et al 1990), this study should include end users from clerical staff, managers in production, purchasing, sales, marketing, and various engineering functions. It was hoped to have the end users scattered in these functional areas rather than having them from one organisational function.

In an attempt to achieve these aims, data collection was carried out in two stages with two different sets of finalist students according to their training year. Each stage involved students from different departments within Loughborough University. Three major types of courses were used to draw the study sample. The following three types of courses and programmes were covered:

I. Business School (Management Sciences, Accounting and Finance, Banking, Retailers, and European Studies)

II. Engineering (Civil, Mechanical, Electrical & Electronics, Chemical)

III. Sciences (Chemistry).

Data available from these programmes indicated that these students met the criteria just mentioned. These students had indeed been spread across all UK sectors during their one year employment and had been scattered through all functional areas.

Method of Access

The method of accessing end users during the data collection process is of vital importance due to the bias effects which might be inherited in the research results. In his field of study of EUC, Benson (1983) declared that a built-in bias must be recognised in obtaining access through IS management.

In considering the method of access to the current study's sample of end users, a literature search for the methods of access was carried out. From the studies reviewed, it was found that end users were accessed in the following methods:

⇒ end-users were accessed via IS management (Benson 1983; Nelson et al 1987; Rivard et al 1988; and Doll et al 1988).

⇒ end-users were identified by managers within a specific organisational unit (Lee 1986).

⇒ end-users were accessed in class rooms as students (Baggozi et al 1992; Davis et al 1989; Galletta 1993; Davis 1993) or on training courses as trainees (Carlsson 1988).

From these three methods, the third method was chosen as the most appropriate to access the study's sample of end users. As each school within the university has an administrator in charge of the industrial year training programme, these administrators were visited to obtain the relevant information about which of their students who had been out on industrial training in their previous year. After that, formal arrangements were made with each class lecturer to access students during his/her lecture. A difficulty was met in separating those students who used spreadsheets during training from those who didn't but this was solved by asking students during the lecture to raise hands to affirm their individual applicability. It is thought to be logical since the incentive was so small that almost none would claim to be applicable if he/she was not.

THE QUESTIONNAIRE METHOD

The "supported" questionnaire approach was adopted for this study to obtain data from end users. The administration and use of this approach was carried out during normal class sessions of finalist students of Loughborough University of Technology over two academic terms.

To maximise survey response rate, three key points were worthy of consideration while conducting this approach:

- Minimising the cost for responding;
- Maximising the reward for doing so;
- Establishing trust that the rewards would be delivered.

These three points were adopted from Dillman's (1978) Total Design Method (TDM), as he proposes a method which pays attention to all factors which affect both quantity and quality of response. However, the complete TDM was not applied to this study as it is more geared to the straight-forward mail questionnaire surveys.

To minimise the cost for responding, departments with final year students who had been in training in industry were located through the students records office of the university. Following that, relevant students were approached during normal class sessions in the university campus thereby saving the costs of mailings and reminders. This was done after prior arrangement with the lecturer either verbally or by sending an internal letter asking for permission to access his/her class at the beginning or the end of the lecture.

Respondents may incur costs in terms of time and effort required for responding. Minimising these costs can be achieved in various ways (recommended by Dillman) if the questionnaire is:

(1) short,

(2) clear and concise,

(3) and has an attractive layout.

Short version scales were deliberately chosen and applied for this study, all questions were close-ended, and almost all of them were circling numbers or ticking boxes. These were direct measures taken to minimise the length of the questionnaire.

Using pre-tested scales and revising the wordings of questions and instructions during the pilot study (discussed in Chapter 5) was considered necessary to have a clear and concise questionnaire.

Besides all of that, presenting the questionnaire in an attractive layout was kept in mind during the whole questionnaire design process.

Moreover, to minimise time costs, lectures before lunch time were deliberately chosen so that respondents could fill in the questionnaire and receive their rewards directly after the lecture, thereby minimising loss of the students' time. At other points in the day students might be pushing on to another lecture, but at lunch time they have a few minutes to spare.

To maximise the rewards for responding, Dillman differentiated between two types of rewards: (1) tangible (2) intangible, and argued that most rewards researchers can offer to respondents are few. He stressed that those rewards which the researcher does have at his or her disposal are mostly intangible but the power to reward should not be underestimated.

Among few other types of intangible rewards, two were thought to be of greater appeal to respondents:

- Explaining to someone that they are part of a carefully selected sample and that their response is needed if the study is to be successful represents a way of expressing positive regard for respondents.
- Approaching respondents with a message that they are being "consulted" has been pointed to be as a means of providing a reward to people while getting needed information.

Both points were implemented in the covering page of the questionnaire and verbally stressed at the beginning of each data collection session.

As far as tangible rewards are concerned, at the beginning of each data collection session the researcher emphasizes the main points of the study and the type of respondents who should fill in the questionnaire and finally declares the type and amount of the tangible reward for each completed questionnaire.

Deciding the type and value of the reward to be delivered was considered to be an important concern to respondents. Many types of rewards were listed as good options. A university brand of a mug, shirt, or pen were among those thought to be of an appeal to most respondents. Realising the difficulty of buying and distributing hundreds of these rewards, it was decided to give a cash reward of the value of 2-3 pints of a suitable middle class beverage with an average cost of 1 pint per £1.

In similar studies, some researchers gave £1 while others were generous in giving £5. These amounts were thought to be on two opposite extremes as £1 is rather low whilst £5 is too costly. In order to make the reward of acceptable appeal while maintaining a reasonable budget, it was decided to be set at £3 in the first term. As response rate was so good in this first stage, the reward was reduced to £2 in the second term.

To establish trust that the rewards would be delivered, the relevant moneys would be brought to the class room. As the researcher describes the objectives of the study and who should fill in the questionnaire, he will display briefly the reward and thus establish trust that rewards will be delivered immediately after completing the questionnaires. Having the reward in cash adds further trust as supported by Dillman's argument that monetary incentives are in fact a symbol of trust.

Regarding trust related to intangible rewards, the specific lecturer was asked to briefly introduce the researcher and the aim of the study and to define the type of eligible respondents, the students' lecturer communication plays an important role in establishing trust as argued by Dillman. Another point recommended by Dillman in this regard is to utilise name(s) of important organisation(s) (e. g., a university) being interested in the research results which may encourage respondents to positively respond to the study. The "University" was mentioned to be interested in the study to enhance the quality of the one year training programme.

The next chapter discusses the development of the questionnaire, its content and its testing.

Chapter 5

QUESTIONNAIRE CONTENT

The research framework discussed in Chapter 3 identified seventeen major variables. This chapter shows how questions on each of these variables were developed and incorporated into a questionnaire. The items used to construct each variable were adapted to make them specifically relevant to spreadsheets usage by students who had been in industrial training for a year. Respondents were specifically addressed as if they were still on the industry year. The complete questionnaire is shown in Appendix A.

In the terms used by those researching structural models (e.g., Joreskog and Sorbom 1986, Loehlin 1987, Bollen 1989), most of the major variables of their studies would be called *latent* variables. This indicates that the variable is quantifying an underlying psychological construct which can not be measured directly. Such constructs can only be measured when a suitable set of observable items have been developed to operationalise the latent variable in question. It is usual to develop several items (sometimes called scales by other researchers) which attempt to operationalise any one particular variable. Each item is a specific question with a possible scale of responses. The latent variable score is derived from the set of scale responses to each item and this is discussed in Chapter 8. The set of items used to operationalise one latent variable is often called an *instrument*. This terminology will be used in the current chapter, however, in Chapter 7 the term *scale* will be used interchangeably with the term *instrument*, when discussing the measurement of constructs, since many authors when examining issues of reliability and validity seem to prefer the term *scale*.

Several relevant instruments that have recently been developed and validated, and published in leading journals are adopted for this study. Some instruments have been reported in short and long versions. The short version items are the strongest items in the long version and recommended by developers for inclusion in short

VARIABLES RESEARCHED AND THEIR INSTRUMENTS

INSTRUMENTS FROM PRIOR RESEARCH

The four studies below form the backbone for building the items used to operationalise two instruments for the first two variables (*Relative Advantage* and *Ease of Use*):

(1) Davis (1989),

(2) Moore and Benbasat (1991) — short and long version of instruments,

(3) Adams et al (1992),

(4) and Davis (1993).

Relative Advantage (Questions 1-8)

From these four studies the eight most common items were identified for the variable *Relative Advantage*. Thus the variable *Relative Advantage* was viewed as a unidimensional multi-item variable with no one obvious or recognised method of optimum measurement. The number of original items that Davis (1989) started with was 14 and this was reduced to an instrument of 6 items. Adams et al (1992) replicated the work of Davis in two studies and concluded that the psychometric properties of the 6 items instrument appeared to have been robust across studies and user groups. Moore and Benbasat (1991) started with a 14 items instrument which was eventually reduced to 9 items.

Though he is the developer of the 6 items instrument in 1989, in a more recent study, Davis (1993) used the 6 items instrument with 4 new items added, which result in a 10- item instrument. This study adopted a broader approach by considering the most common 8 items between at least two of those four studies to constitute the *Relative Advantage* instrument.

Essentially, the Davis (1989) 6-item instrument constitutes the groundwork of the instrument. Two extra items were added to it from the work of Moore and Benbasat (1991). The psychometric properties of the 8 items instrument will be discussed in Chapter 7.

The following is a list of these eight items (numbers in brackets beside each item indicate the studies mentioned above that adopted it):

- Enabling quick tasks accomplishment [1, 2, 3, 4]
- Improving work performance [1, 2, 3, 4]
- Increasing productivity [1, 2, 3, 4]
- Enhancing effectiveness [1, 2, 3, 4]
- Making work easier [1 , 2, 3, 4]
- Overall advantage [1 , 2, 3, 4]
- Improving work quality [2, 4]
- Giving control over work [2, 4]

Each of these eight items was incorporated into a question, something like:
"Using spreadsheets enabled me to accomplish some tasks more quickly." Individuals were asked to indicate the extent of agreement or disagreement with the instrument statements on a five-point Likert-type scale ranging from (1) *Strongly disagree* to (5) *Strongly agree.*

Ease of Use (Questions 12-19)

The *Ease of Use* variable is also a unidimensional multi-item variable measured by six different items in this study. *Ease of Use* instrument went through the same development process as the *Relative Advantage* instrument. Initially eight dimensions were drawn from the same studies listed above, but two dimensions were finally dropped.

Davis's (1989) Ease of Use instrument is formed of six items, while Moore and Benbasat's instrument has two more items besides these six items. Davis's (1993) Ease of Use instrument contains Moore and Benbasat's eight items with two further items. This study adopted the most common 8 items between these studies dropping two items and retaining six items for this instrument after reliability analysis to be discussed in Chapter 7.

The chosen six items are listed below with the numbers of studies beside the item that adopted it (the two items marked with [°] are dropped):

• Cumbersome of usage (reverse scored) [1,2,3,4]

• Ease of Learning [1,2,3,4]

° Frequency of frustration when using the system [2,4]

• Ease of doing what user wants to do [1,2,3,4]

• Ease of remembering how to do tasks [1,2,3,4]

° Requiring a lot of mental efforts (reverse scored) [2,4]

• Interaction with the system being clear and understandable [1,2,3,4]

• Overall Ease of Use [1,2,3,4]

The questions based on these items were all something like:
"I believe that it was easy to get spreadsheets to do what I want it to do while in industry." Individuals were asked to indicate the extent of agreement or disagreement with the instrument statements on a five-point Likert-type scale ranging from (1) *Strongly disagree* to (5) *Strongly agree.*

Compatibility (Questions 9-11)

Initially the *Compatibility* instrument consisted of three items. They comprise the short version of Moore and Benbasat's (1991) *Compatibility* instrument. To improve the instrument reliability level for this study sample, the first item (marked with °) was dropped retaining only two items for this instrument. The two items of the *Compatibility* instrument used for this study are listed below:

° Compatibility with all aspects of the work

• Fitting the way of doing the work

• Fitting the work style

Each of these three items was incorporated into a question, something like: "Using spreadsheets fitted with the way I liked to do some tasks in my work". Individuals were asked to indicate the extent of agreement or disagreement with the instrument statements on a five-point Likert-type scale ranging from (1) *Strongly disagree* to (5) *Strongly agree.*

Voluntariness (Questions 20-22)

The *Voluntariness* instrument consists of three items. They comprise the two items of the short version of Moore and Benbasat's (1991) *Voluntariness* instrument plus one more item of the long version which was added to enhance the reliability level of the instrument. The third item added here is having the strongest correlation with the instrument items among the rest. The three items of the *Voluntariness* instrument used for this study are listed below:

• Use is voluntary (as opposed to required by superiors or job description)

• Boss did <u>NOT</u> require system use

• Use is certainly <u>NOT</u> compulsory

Each of these three items was incorporated into a question, something like: "My use of spreadsheets was voluntary (as opposed to required by superiors or job description)." Respondents were asked to evaluate the above statements on a five-point Likert-type scale with the two extreme points labeled *extremely likely / extremely unlikely.*

Image (Questions 26-28)

The *Image* variable was measured using a 3-item five-point Likert-type scale. This instrument was adopted from the short version of the *Image* instrument developed by Moore and Benbasat (1991). The three items of the *Image* instrument used for this study are listed below:

- People using spreadsheets have more prestige than those who do not
- People using spreadsheets have a high profile
- Using spreadsheets is a status symbol

Each of these three items was incorporated into a question, something like:
"People in my employing organisation who use spreadsheets have a high profile." Respondents were asked to evaluate the following statements with the two extreme points labeled *extremely likely / extremely unlikely.*

Enjoyment (Questions 23-25)

The *Enjoyment* variable was measured using a 3-item instrument. This instrument was adopted from the work of Davis et al (1992) when they tested extrinsic and intrinsic motivation to use computers in the workplace. The three items of the *Enjoyment* instrument used for this study are listed below:

- The use of spreadsheets is enjoyable
- The actual process of using spreadsheets is pleasant
- Having fun while using spreadsheets

Each of these three items was incorporated into a question, something like:
"Based on my industrial experiences, I believe using spreadsheets to be enjoyable." Respondents were asked to evaluate the above statements on a five-point Likert-type scale with the two extreme points labeled *extremely likely / extremely unlikely.*

Normative Beliefs and Motivation to Comply (NBMC) (Questions 29-32)

NBMC instrument appears to be constituting of two dimensions: (1) normative beliefs (NB) (2) motivation to comply (MC). Thus NBMC is a 2-dimensional multi-item variable. From the work of Ajzen and Fishbein (1980), two elements were found to be the most influential to individual normative beliefs in the work place:

⇒ People the individual closely works with

⇒ The public bulk or most of the people in the organisation.

A five-point Likert-type scale of four items is used in this study to evaluate the influence of these two elements on the individual and how he or she is motivated to comply with them. Respondents were asked to evaluate the following statements with the two extreme points again labeled *extremely likely / extremely unlikely*:

- Most people in my employing organisation thought I should use spreadsheets.
- Generally speaking, I wanted to do what most people in my employing organisation thought I should do.
- The people I worked closely with thought I should use spreadsheets.
- Generally speaking, I wanted to do what most people I worked closely with thought I should do.

Subjective Norms (Question 33)

Ajzen and Fishbein (1980) used a single-item instrument for the *Subjective Norms* variable. This study adopted the same single-item instrument to evaluate the subjective norms of the individual, whether he or she should use spreadsheets to accomplish work tasks. The single item statement was worded as:

- Most people who were important to me thought I should use spreadsheets.

Respondents were asked to evaluate the above statement on a five-point Likert-type scale with the two extreme points also labeled as *extremely likely / extremely unlikely*.

Attitude (Questions 34-38)

Attitude toward using spreadsheets was measured using five standard five-point semantic differential rating scales as suggested by Ajzen and Fishbein (1980) and used by Davis (1993) for operationalising attitudes toward behaviours.
Respondents were asked to evaluate the following statements:
"All things considered, my using spreadsheets in accomplishing various tasks in industry was:

- Good — Bad;
- Wise — Foolish;
- Favourable — Unfavourable;
- Beneficial — Harmful;
- and Positive — Negative".

Each of these semantic differential adjectives was portrayed on a five-point scale, something like:

	extremely	quite	neither	quite	extremely	
Bad	______:	______:	______:	______:	______	Good

and respondents are asked to make a cross mark in the place that best describe their opinion.

End-User Computing Satisfaction (EUCS) (Questions 39-47, 19)

EUCS variable was measured by a multi-dimensional instrument of 10 items developed by Doll and Torkzadeh (1988). The instrument used for this study was adapted from the original twelve-item instrument after dropping two items related to timeliness (response time and updating information) which were irrelevant to the spreadsheeting process. The instrument is a measure of overall end-user computing satisfaction as well as satisfaction with the extent to which spreadsheet meets the user's requirements with regard to four dimensions:

- Information content (4 items)
    1. Spreadsheets provided precise information
    2. Spreadsheets information content meet user needs
    3. Spreadsheets provided the exact reports needed
    4. Spreadsheets provided sufficient information
- Accuracy (2 items)
    1. Spreadsheets are accurate
    2. Satisfaction with spreadsheets' accuracy
- Format (2 items)
    1. Output presented in a useful format
    2. Information was clear
- Ease of use (2 items)
    1. Spreadsheets are user friendly
    2. Spreadsheets are easy to use

Because question number 19 is already incorporated in the *Ease of Use* construct, it is not repeated here, but it is used when calculating the final score of the EUCS instrument. Each of these ten items was incorporated into a question, something like:

"Did spreadsheets provide the precise information you need?". Respondents were asked to evaluate each item on a five-point Likert-type scale ranging from (1) *almost never* to (5) *almost always.*

Usage (Questions 48-49, 63-68, 82)

Usage was measured by five items adapted from several studies (Srinivasan 1985; Lee 1986; Igbaria et al 1989; Davis et al 1989; Thompson et al 1991; Davis 1993; Igbaria 1993):

- Time spent on using spreadsheets per day
- Frequency of spreadsheets use
- Number of spreadsheet software packages used and level of usage for each
- Number of applications for which the spreadsheet system is used
- Level of sophistication of usage

Individuals were asked to indicate the amount of time spent on spreadsheets, using a six-point scale ranging from (1) *almost never* to (6) *more than 3 hours per day.* Frequency of use which provides a different perspective of use than time, was measured on a six-point scale ranging from (1) *less than once a month* to (6) *several times a day.*

In an EUC environment, users have a wide choice of spreadsheet packages to use. In such an environment a good indication of overall spreadsheet acceptance can be provided by measuring the number of different packages used and the level of usage for each. A list of the five most commonly used spreadsheet packages was given (with an option *"other, if any"* to be specified by the respondent) and respondents were asked to indicate the level of use of each one of these packages on a five-point scale ranging from (1) *none* to (5) *extremely extensive.*

The number of applications for which the spreadsheet system was used by the participants can be another indicator of the user acceptance of spreadsheets. For the purpose of this study, a five-point scale was used to measure this item ranging from (1) *just one application* to (5) *more than 10 applications.*

In addition, level of sophistication of spreadsheet applications (e.g., using macros, menus, data validation, etc.) used by the participants was used as an indicator of the user acceptance of spreadsheets. This item was measured using a five-point scale ranging from (1) *least sophisticated* to (5) *highly sophisticated.*

Spreadsheet System Rating (Questions 73-78)

The measure of *Spreadsheet System Rating* variable adapted for this study from Igbaria and Chakrabarti (1990) consists of a single-item instrument. Respondents were given a list of the five most commonly used spreadsheet packages with an option *"other, if any"* to be specified by the respondent. The five most commonly used spreadsheet packages were drawn from the preliminary study about the finalist students one year training in industry. The following is a list of these packages:

1. LOTUS 1-2-3
2. SUPERCALC
3. QUATTRO PRO
4. EXCEL
5. SYMPHONY

The *Spreadsheet System Rating* single item was incorporated into a question like: "For those spreadsheets package(s) I have worked with or used, I found the overall characteristics to be."

Respondents were asked to rate their overall perception of the spreadsheets system characteristics they used by evaluating the above statement on a five-point scale ranging from (1) *Poor* to (5) *Excellent.*

INSTRUMENTS DEVELOPED IN-HOUSE

Three instruments were wholly developed in-house for the purpose of this study with the exception of some work as mentioned under end user computing support instrument. They were built based on a preliminary study that had been applied in previous years with some finalist students. The following are the three instruments:

1. End-User Training
2. End-User Computer Experience
3. End-User Computing Support

These instruments had been piloted in previous years with some finalist students and had therefore undergone several refinements. This was done to ensure that these instruments fully measured all sources of training, EUC experience, and EUC support provided for students in their year out in industry.

End-User Training (Questions 83-92)

Respondents were asked to identify the sources that contributed to the increase of their spreadsheets knowledge and expertise during their industrial placement. Four broad categories were incorporated in an in-house developed instrument to measure *End-User Training*.

The four categories of the end-user training instrument were as the following:

- A colleague explained spreadsheets features (trainee/member of staff) [2 items]
- A spreadsheets expert explained features (departmental/central) [2 items]
- A course on spreadsheets (package features/model building/advanced features) [3 items]
- Self study using (manuals/tutorial package) [2 items]

End-User Training was measured by individual responses to nine questions which asked them to report the extent of training in spreadsheets they had received from each specific source. Each of these nine items was incorporated into a question, something like:

"A member of staff explained spreadsheets features."

The response options ranged from (1) *none* to (5) *extremely extensive.*

End-User Computing Support **(Questions 96-104, 108-112)**

The instrument used to measure *End-User Computing Support* incorporated two broad categories of support:

I. Application development support, which is quite specific, and includes the availability of development assistance, specialised instruction, and guidance during the spreadsheeting process;

II. General support, which includes top management encouragement and allocation of resources.

End-User Computing Support instrument consists of 13 items, eight representing the specific support which were developed in-house for this study, and five items of general support (management support) which were adopted by Igbaria (1990). The eight items were measured using similar questions to those used in measuring *End-User Training.*

Each of the five items of general support was incorporated into a question something like:

"There was a person available to whom computer users could turn to for help."

Respondents were asked to evaluate each item on a five-point Likert-type scale ranging from (1) *almost never* to (5) *almost always.*

End-User Computer Experience (Questions 113-124)

End-User Computing Experience was assessed by ten items asking respondents to indicate their general experience in using computers, programming languages, and packaged application software. Also, they were asked specifically about their experiences and skill level in using spreadsheets.

Some of the response options were *yes/no* (dichotomous) and filling number of years of experience. Other response options ranged from (1) *low* to (5) *high* and from (1) *none* to (5) *extremely extensive.*

Type of Course (Question 128)

There are two demographic variables researched in this study: (1) Course (2) Gender. Respondents were asked to identify the course or type of programme in which they are registered at the university. Four major courses/types of programmes, with one dropped later, were listed for respondents to identify:

- A Business Programme
- An Engineering Programme
- A Science Programme

° Computer/Information & Library Studies

Computer/Information & Library Studies course was dropped later as a precaution that end users of this course might not fall under the type of end users defined earlier in Chapter 4 for the purpose of this study.

Gender (Question 129)

Finally, respondents were asked to identify their gender, which is the second demographic variable researched in this study:

(1) Male

(2) Female

PILOT STUDY

After reviewing the literature related to the study, the research model and variables were identified. Successive drafts of the questionnaire were produced. These drafts were repeatedly discussed with several academics until the final questionnaire draft emerged. Then, a pilot test for the final questionnaire was carried out which is discussed subsequently.

As suggested by Dillman (1978), the questionnaire was pre-tested by two different groups: colleagues (PhD students) and final year students. In all, seven sets of useful feedback were obtained. The pilot response rate was 70% which was not the main point behind running the pilot study. In fact, the main point was to achieve more clarification regarding the wording of both questionnaire instructions and questions. Improving these aspects lead to higher explanation rate which is considered to be one of the major weaknesses of questionnaire surveys

Beside that, another important outcome of the pilot study was to know the average time needed to fill in the questionnaire completely. This point is of paramount importance in judging the reward value (discussed in Chapter 4) appropriate for the time spent in filling the questionnaire.

Pilot study analysis

The responses were analysed in relation to the type of group. Table 5.1 shows the type of group and their responses.

Group type	Number	Returned	%
PhD students	5	4	80
Finalist students	5	3	60
Total	10	7	70

Conclusions from the pilot study

The pilot study provided feedback on the questionnaire itself. Several aspects were reconsidered with regard to both the whole questionnaire style and specific questions. The following are the main aspects reconsidered for the final copy of the questionnaire:

1) Emphasizing some words using capital letters and underlining (Q8, Q19, Q21, Q22).
2) Rewording of some questions and instructions.
3) Rearranging the sequence of some questions.
4) Incorporating additional packaged application software.
5) Adopting the five-point scale, as respondents were found not differentiating significantly between the two adjacent marking positions of *slightly* and *quite* in the seven-point scale.
6) The average time spent in filling the questionnaire was 12 minutes.

As a result, the questionnaire was revised before the data collection process. The final copy of the questionnaire is given in Appendix A.

Chapter 6

THE SAMPLE

This chapter discusses the descriptive findings of the survey questionnaire. Fuller details are provided in Appendix B, where summarised responses to specific questions are given.

THE RESPONDENTS PROFILE

Having defined the units of analysis (end-users) as in Chapter 4, it is possible to identify the total number of potential respondents in order to arrive at a good approximation of the survey response rate. By examining the university records of which students went on placements, the total number of potential respondents was found to be 497 which includes those who did not use spreadsheets. There was no way of telling which of these potential respondents had actually used spreadsheets in their training from those who had not. From a preliminary study carried out in the Business School it was found that about 85% of those who went for one year training in industry did use spreadsheets. This percentage was taken as a standard for all students in this survey. The actual number of respondents to the survey questionnaire was 333. Thus the response rate for the survey was calculated using the following formula:

$$\text{response rate} = [(333)/(497 \times 0.85)] \times 100 = 79\%.$$

Interestingly, the response rate was found to be in the range of 70%, as was predicted earlier in the research design (Chapter 4).

The rest of this chapter shows the first attempt to unveil what Marsh (1988) called "what does this data say?". The following are some tables showing the respondents' profile as early findings of the survey questionnaire.

End-Users Demographics

As expected, many of the respondents were from the business area (59%). Engineering respondents were (34%) and sciences were only (7%) of the sample. The low percentage of sciences was due to the fact that at Loughborough University few science departments incorporate the one year industrial training as part of the degree programme, so chemistry students were the only sciences students contacted for data collection in this study. Table 6.1 shows the distribution of end-users by type of department.

Table 6.1: End-Users by Type of Department

Department Type	Number	%
Business	197	59
Engineering	133	34
Sciences	23	7
Total	333	100

Gender is the second demographic variable researched in this study. The respondents profile in the study sample shows that males were about two-third (68%) and females were about one-third (32%) of respondents. An interesting finding here was that the distribution of end-users by gender reflects the standard at Loughborough University which split in a ratio of 2 men to 1 women. Table 6.2 shows the distribution of end-users by gender.

Table 6.2: End-Users by Gender

Gender	Number	%
Male	228	68
Female	105	32
Total	333	100

EUC Experience

EUC experience assesses the actual experience in using computers, spreadsheets, and packaged application software of end users.

The majority of respondents have had 3 to 5 years (44%) or 6 to 10 years (43%) of computer experience. More than half of them (54%) haven't written programmes in computer languages which indicates the importance of spreadsheets packages as a ready alternative to them. Most of those who have programmed in computer languages (36%) have 1 to 5 years of some programming experience. Most of respondents (61%) have 3 to 5 years of experience with spreadsheets, (14%) have one year, (17%) have two years, (8%) have 6 to 10 years, and none has experience with spreadsheets more than 10 years. Table 6.3 below shows more details.

Table 6.3: End-Users Computer, Programming, and Spreadsheets Experiences

Years of Experience	General Computer Experience (%)	Writing Computer Programs (%)	Years of Using Spreadsheets (%)
1 Year	3	10	14
2 Years	5	13	17
3-5 Years	44	13	61
6-10 Years	43	8	8
Over 10 Years	5	2	—
Total	100	46 *	100

* (54%) of respondents did not write any programmes in computer languages.

Attitude toward spreadsheets

The distribution of the five ratings used to measure respondents attitude toward spreadsheets is shown in Table 6.4. The last column shows the total of above average response to each attitudinal attribute given.

Table 6.4: Attitude toward spreadsheets

Attitude toward spreadsheets			
Adjective	% Quite	% Extremely	% of Total Above Average Response
Good	67	29	96
Wise	59	30	89
Favourable	61	30	91
Beneficial	44	50	94
Positive	55	38	93

End-User Computing Satisfaction (EUCS)

The sample findings of the EUCS instrument are showing an overall assessment of spreadsheets and comparing end-user satisfaction with specific components(i.e., content, format, accuracy, or ease of use). Percentile scores for the 10-item EUCS instrument are presented in Table 6.5. Other relevant sample statistics are: minimum = 19; maximum = 50; mean = 39.07; median = 40; and standard deviation = 4.61.

Table 6.5: Percentile Scores—10-Item EUCS Instrument

Percentile	Value
10	33
20	36
30	37
40	39
50	40

Percentile	Value
60	40
70	42
80	43
90	45

Spreadsheets Usage

Spreadsheets usage as the research dependent variable was measured by five indicators in order to present it in a full picture:

- Daily use
- Usage frequency
- Application sophistication level
- Number of applications
- Level of usage

The distribution of respondents by each of these indicators is discussed below supported with summary tables (Table 6.6. — Table 6.10).

Spreadsheets daily usage

One quarter (25%) of respondents reported to have been using spreadsheets for 1/2 to 1 hour daily and (12%) for less than 1/2 hour daily. (22%) of respondents used spreadsheets for more than 3 hours daily and equivalent portion used it for 1 to 2 hours daily. (16%) used spreadsheets for 2 to 3 hours daily. Table 6.6 shows the distribution of end-users daily usage of spreadsheets

Table 6.6: Spreadsheets Daily Usage by Respondents

Spreadsheets Daily Usage	% Respondents
More than 3 hours	22
2 - 3 hours	16
1 - 2 hours	22
From 1/2 - 1 hour	25
Less than 1/2 hour	12
Almost never	3

Frequency of usage

The distribution of spreadsheets usage frequency is skewed with many users of frequent daily and weekly using spreadsheets (Table 6.7). (31%) of respondents reported to use spreadsheets for several times a day, (32%) used spreadsheets for few time a week, (16%) used spreadsheets about once a day, and (14%) used spreadsheets for a few times a month. The details frequency of spreadsheets usage by respondents are given in Table 6.7.

Table 6.7: Spreadsheets Usage Frequency

Spreadsheets Usage Frequency	% Respondents
Several times a day	31
About once a day	16
A few times a week	32
A few times a month	14
Once a month	4
Less than once a month	3

Sophistication of Spreadsheets Applications

Spreadsheets applications sophistication level was measured in terms of using macros, menus, and data validation. Table 6.8 shows levels of sophistication of spreadsheets applications used by respondents in industry.

Table 6.8: Sophistication Level of Spreadsheets Applications Used

Level of Sophistication	% Applications
Highly sophisticated	15
Quite sophisticated	44
Average	28
Below average	10
Least sophisticated	3

Number of spreadsheets applications used

Respondents were asked to report number of different spreadsheets applications they used while in industry. The median number of applications used was 2. Table 6.9 shows respondents distribution by number of applications used.

Table 6.9: Number of Different Spreadsheets Applications Used by Respondents

Number of Applications Used	% Respondents
Just One Application	35
Two Applications	31
3 to 5 Applications	28
6 to 10 Applications	3
More than 10 applications	3
Total	100

Level of Usage

Respondents were asked to rate their level of usage for the different spreadsheets packages they used while in industry. The median (62%) was extremely extensive level of usage. Table 6.10 shows respondents distribution by level of usage.

Table 6.10: Respondents Distribution by Level of Usage

Level of Usage	% Respondents
Extremely Extensive	62
Quite Extensive	29
Average	7
Below Average	2
Total	100

The distribution of the five manifestation items of spreadsheets usage variable is shown in Table 6.11. Median and lower and upper quartiles of these indicators reflect high profile of spreadsheets usage from five different perspectives.

Table 6.11: Spreadsheets Usage by Respondents

Usage Indicator	Lower Quartile	Median	Upper Quartile
Daily Use	1/2 - 1 hour	1 - 2 hours	2-3 hours
Usage Frequency	few times/week	few times/week	several times/day
Sophistication	average	quite	quite
No. of Applications	one	two	3 to 5
Level of Usage	extensive	extrem. extensive	extrem. extensive

Table 6.12 show usage and rating of overall characteristics of the five spreadsheets packages surveyed. There is some reservation about the ratings of packages as some organisations might not be updating their old packages versions. Reported rate for each package characteristics is summing up all versions were in use.

Table 6.12: Usage and Overall Rating of Spreadsheets Packages Characteristics

		% Rating of Overall Characteristics		
Spreadsheets Package	% Used	Below Average	Average	Above Average
LOTUS 1-2-3	73	3	18	52
EXCEL	60	2	5	53
SUPERCALC	19	5	9	5
QUATTRO PRO	18	—	7	11
SYMPHONY	7	1	4	2

Table 6.13 below show types and distribution of applications where spreadsheets are implemented in industry. Many respondents noted that they might not be aware about other possible spreadsheets applications outside their functional area.

Table 6.13: Applications of Spreadsheets in Industry

Application Name	% Spreadsheets Applied
1. Business Analysis / Planning	66
2. Marketing	36
3. Pricing / Quoting	40
4. Accounting / Financial Analysis	70
5. Budgeting	59
6. Personnel	32
7. Forecasting	57
8. Purchasing	29
9. Production Planning / Scheduling	37
10. Stock control	32
11. Others	19

End-User Computing Support

For a more clear descriptive picture of EUC support provided for end users in the workplace, EUC support is reported below as two categories: (1) spreadsheets application development support (Table 6.14) and (2) general EUC support (Table 6.15).

Table 6.14: Spreadsheets Applications Development Support Sources

Type of Support Provided	% of average and above
Manuals	80
Online help	67
Tutorial package	53
Trainee	43
Member of staff in the area	72
Spreadsheets expert in the area	30
Central spreadsheets expert	24
Hotline to spreadsheets expert	24

The support which end users were provided with during spreadsheet applications development was mostly through self-support, member of staff, and spreadsheets expert respectively. Table 6.14 shows the percentages of average and above levels of different sources of support.

The general support, which includes top management encouragement and allocation of resources was found according to Table 6.15.

Table 6.15: General End-User Computing Support

Type of support	Lower Quartile	Median	Upper Quartile
Person available for help	26%	54%	100%
Central support	33%	55%	100%
Training courses	42%	64%	83%
Management provided most necessary resources	44%	70%	93%
Management keen for user satisfaction	35%	65%	88%

From Table 6.15, it can be seen that there are some lacks of training courses and management support.

End-User Training

Respondents provided training sources on spreadsheets were found to be arranged as through self study, member of staff, colleague or trainee, tutorial package, course on spreadsheets package features respectively. End users were found to be highly self-dependent (90%) followed by unprofessional training from a member of staff (67%) or another trainee (45%), professional training occupied only 35%. Table 6.16 shows the different training sources on spreadsheets provided in industry and percentages accommodated of each source.

Table 6.16: Training Sources on Spreadsheets

Spreadsheets Knowledge and Expertise Sources	% of average and above
A trainee explained features	45
A member of staff explained features	67
A spreadsheets expert explained features	30
A central spreadsheets expert explained features	19
A course on spreadsheets package features	35
A course on spreadsheets model building	15
A course on spreadsheets advanced features	17
Through a tutorial package	47
Through self study	90

Unprofessional training provided to spreadsheets end users have manifested in many risks reported in the literature (e.g., Creeth 1985; Freeman 1986; Ditlea 1987). Organisations should invest more in professional training to minimise these risks and for their competitive advantage.

Benefits

Most end users felt that using spreadsheet systems had been very beneficial from different viewpoints. For example:

97% felt it improved the quality of the work

78% felt it gave them greater control over their work

96% felt it enabled them to accomplish tasks more quickly

84% felt it increased their productivity

87% felt it improved their job performance

86% felt it enhanced their effectiveness on their work

94% felt it made it easier to do their work

96% rated, overall using spreadsheets, to be advantageous.

The previous statements refer to the relative advantage of using spreadsheets. This is reflecting that using spreadsheets is perceived as being relatively advantageous to using its precursor which is most probably paper and pencil as 54% of respondents had no experience in programming languages.

These statements support the claims that *relative advantage* is a very important determinant factor of system usage (Davis et al 1989, Thompson et al 1991, Igbaria 1993, and Davis 1993). Findings regarding *ease of use* as a second important determinant factor of system usage are discussed next.

Ease of use

Findings regarding *ease of use* of spreadsheet systems reflect the following viewpoints :

4% felt that spreadsheets were cumbersome to use
80% felt that learning to use spreadsheets was easy for them
59% felt that it was easy to get spreadsheets to do what they want it to do
71% felt that their interaction with spreadsheets was clear and understandable
87% rated spreadsheet systems, in overall, to be easy to use
77% felt that it was easy for them to remember how to perform tasks using spreadsheets.

The above statements refer to the ease of use of spreadsheets. This is reflecting that using spreadsheets is perceived by the vast majority of end users as being easy. These statements support the claims that *ease of use* is a an important determinant factor of system usage (Davis et al 1989, Thompson et al 1991, Igbaria 1993, and Davis 1993).

A fuller details of the variables researched are provided in Appendix B, where summarised responses to specific questions are given.

Chapter 7

RELIABILITY AND VALIDITY ANALYSIS

Throughout this chapter the term *scale* will be used interchangeably with the term *instrument* when discussing the measurement of constructs. Since many authors when examining issues of reliability and validity seem to prefer the term *scale* over *instrument*, this research will adopt the term *scale* in the same context.

The questionnaire content discussed in Chapter 5 included ten different multiple-item scales adapted from prior research. This chapter discusses both reliability and validity analysis of these scales. For more reliable scales, de Vaus (1991) recommended that "the best course is to use well-tested questions from reputable questionnaires". As mentioned earlier (Chapter 5), nine of these scales have been tested and published in leading MIS journals the tenth of these is the NBMC scale taken from Ajzen and Fishbein (1980). The three in-house developed scales for this study are not subjected to this type of analysis as they are considered informal scales. The four remaining scales were all single-item scales which also can not be subjected to this type of analysis.

Although nine of these scales have been tested, this chapter undertakes replicatory and confirmatory analysis of the previous work of Doll and Torkzadeh (1988), Davis (1989, 1993) , and Moore and Benbasat (1991). To do this, the validity and reliability assessment of the present sample for these scales is discussed here. This is done as Moore and Benbasat (1991) recommend their instrument for application when investigating perceptions of innovations, stating that, "although additional checks for validity and reliability would be prudent after rewording" (p. 211) for different IT innovations. Straub (1989) argued that "researchers should use previously validated instruments wherever possible, being careful not to make significant alterations in the validated instrument without revalidating instrument content, constructs, and reliability" (p. 161).

Scale Reliability

A reliable scale is one on which individuals would obtain much the same scale score on two different occasions (de Vaus, 1991). A good scale is one that yields stable results, that is to say, it is reliable (Norusis, 1985). A reliable measuring instrument behaves similarly, that is, the scale yields similar results when different people administer it and when alternative forms are used. When conditions for making the measurements change, the results of the scale should not change significantly.

Scale Validity

Scale validity can be described in a way such that, the instrument must measure what it is intended to measure (de Vaus, 1991). In fact, it is not the measure that is valid or invalid but the use to which the measure is put. The validity of a measure depends on how we have defined the concept it is designed to measure. One of the most vital steps in developing and/or validating a scale is the conceptual task of defining the construct, in other words, the construct of interest must be clearly and precisely defined (Spector, 1994).

Thus, clarifying concepts of constructs by deciding on a definition for each construct and delineating the dimensions of each one are very important prerequisites for achieving higher scale validity. Although many researchers argue that it is an ongoing process even after analysing data, nevertheless, this process must begin before data collection; this is believed to have been achieved adequately at the right time in earlier chapters reviewing the literature (Chapter 2) and providing the research framework (Chapter 3).

Reliability and Validity

A scale must be reliable to be useful. But it is not enough for a scale to be reliable; it must also be valid. It is wise to assess the reliability and validity of indicators by carrying out secondary data analysis prior to final data analysis. When doing this, two complementary approaches — one conceptual and one empirical — are helpful. First, one can get an idea of which items might go together by looking at their content. By examining the questions in a survey one will identify a number which, on the face of it, would probably tap this concept as we understand it. The second step, is to obtain a correlation matrix of the items that might conceivably belong together. This will provide correlation of each item with each other item. When selecting items from a matrix it is important not to rely only on the correlation magnitude, but the items must also belong together conceptually (de Vaus, 1991).

Reliability and Validity Analysis

The Confirmatory Factor Analysis (CFA) with VARIMAX rotation is used here to assess the scales discriminant validity. CFA is a form of factor analysis in which specific expectations concerning the number of factors and their loadings are tested on sample data; VARIMAX is a method of orthogonal rotation which simplifies the factors structure by maximising the variance of a column of the pattern matrix (Kim and Mueller 1978). The primary criterion for discriminant validity is that each indicator (item) must load more highly on its associated construct than on any other construct.

The internal consistency of these constructs (scales) was assessed by computing Cronbach's alphas. Construct internal-consistency reliability means that "multiple items, designed to measure the same construct, will intercorrelate with one another" (Spector, 1994). This reliability procedure when run for each scale shows how the individual items of that specific scale compete to be incorporated in it whilst maintaining an acceptable level of reliability. There are at least two different methods for the measurement of reliability:

- One can compute an estimate of reliability based on the observed correlations or covariances of the items with each other,
- One can correlate the results from two alternate forms of the same scale into two parts and look at the correlation between the two parts.

The practical limitation of using the alternative-form method is that it can be quite difficult to construct alternative forms of a test (scale) that are parallel (Carmines and Zeller 1979). Therefore, the first method is applied here to measure the Cronbach's alpha for each of the ten scales used in this study.

Thus, the process of reliability and validity analysis for the set of scales was carried out in two successive stages:

I. Validity analysis was carried out by running Confirmatory Factor Analysis (CFA) with VARIMAX rotation applied to make sure that each scale items loads on the target construct, thereby proving scale discriminant validity.

II. Reliability analysis was carried out by computing Cronbach's alpha for each set of items produced from stage (I) to make sure that each construct items maintains an adequate intercorrelation level with one another, thereby proving scale internal consistency reliability.

VALIDITY ANALYSIS

Factor Analysis

Factor analysis is an appropriate and a quite useful method for validating both unidimensional and multidimensional scales (Spector, 1994; de Vaus 1991). The basic aim of factor analysis is to examine whether, on the basis of responses to questions, a small number of more general factors that underlie answers to individual questions can be identified. In other words, whether some variables tend to cluster together.

Factor analysis was used here to assess the scales' construct validity. Fornell (1983) has argued that, in traditional factor analysis, the results are "intermediate" because factor loadings can be rotated in numerous ways. Thus, data analysis where possible ought to be grounded in strong ***a priori*** notions (Moore and Benbasat 1991). This fits the approach in this research where the constructs of interest are based on a substantial body of prior research (e.g., Tornatzky and Klein 1982; Rogers 1983; Doll and Torkzadeh 1988; Davis (1989); and Moore and Benbasat 1991).

Maximum Likelihood (ML) analysis was conducted with VARIMAX rotation. ML is a criterion by which a number of common factors are extracted, with an overall objective of finding the factor solution, which best fit the observed correlations between variables. Kim and Mueller (1978) argued that "employing a method of orthogonal rotation (i.e., VARIMAX) may be preferred over oblique rotation, if for no other reason than that the former is much simpler to understand and interpret" (p. 44).

CFA would be used to indicate how well a set of data fits a hypothesized structure. However, the analysis will not be pure CFA as it will be partially exploratory for two factors. The first, *Compatibility* was found to be a problematic construct by Moore and Benbasat (1991) because it did not load cleanly as a separate factor. Secondly, the analysis also includes the addition of a relatively new construct *NBMC*. The CFA will consider 10 factors, but one of these is EUCS. Doll and Torkzadeh (1988) explain that EUCS is multidimensional with 5 sub-factors. However, one of these sub-factors (Timeliness) was excluded from this study so there are 4 sub-factors of EUCS and 9 unidimensional factors.

As CFA allows for the statistical testing of a hypothesized factor structure. Hence, with the ten scales structure used in this study, it was posited that a structure of 13 factors will emerge where each item loads on its scale and according to the above described structure.

Using the sample of 333 responses, the data was examined using maximum likelihood analysis as the extraction technique and VARIMAX as a method of rotation. Initially, CFA was run without specifying the number of factors. But in this first run exactly thirteen factors with eigenvalues greater than one emerged. However, these 13 factors were not exactly those expected, as will be explained later. Those 13 factors are interpreted as:

Factor #	Factor Title or Construct Name
1	Relative Advantage
2	Ease of Use
3	Attitude
4	Image
5	Usage
6	Enjoyment
7	Voluntariness
8	End-User Computing Satisfaction (EUCS) — Content
9	" " " " EUCS — Accuracy
10	End-User Computing Satisfaction (EUCS) — Format
11	Normative Belief and Motivation to Comply (NBMC) — NB
12	" " " " " NBMC — MC
13	Compatibility

Except for two issues, all the other 11 factors met precisely the most expected interpretable structure. To explore other factoring possibilities, the analysis was conducted specifying ten, twelve, and fourteen factors. In the case of ten and twelve factors, some of previous 13 factors were merely amalgamated. In the case of 14 factors, one of the original 13 was divided with one variable on its own. It was felt that specifying 13 factors resulted in the most interpretable structure. The results indicate that a thirteen-factor solution was the most appropriate as 13 factors had eigenvalues greater than 1.0 as a rule of thumb, while the Scree-Test plot also showed a break after the 13th factor. The thirteen factors accounted for approximately 64.3 % of the variance in the data set.

In Table 7.1, the items are grouped by their strongest (primary) factor loading. Next, the rotated factor matrix was examined for items which either did not load strongly on any factor, or did not load at all on any factor. Although there is no absolute rule as to how strong a coefficient should be before it is said to load on a factor, following Moore and Benbasat (1991), coefficients below 0.40 were discarded. Thus, all loading values greater than 0.4 are shown and none less than 0.4 are given, except as asterisks (**) in few cases.

As a result, four items were found not to load strongly (less than 0.4) on their target constructs: two items of *Ease of Use*, one item of *Usage*, and one item of *Compatibility* did not load strongly. These four items were candidates for possible deletion from the three scales. A very important point to note was that for every single item there was no factor loadings above 0.40 on additional (non-primary) factors (i. e., no complex or problematic factor loadings). This led to the fairly simple factor structure as depicted in Table 7.1 below.

Table 7.1: Rotated Factor Pattern Matrix and 13 Factors Extracted

Item Code	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
RA4	.67103				
RA3	.62694				
RA8	.62320				
RA5	.58440				
RA6	.53705				
RA7	.51180				
RA1	.43766				
RA2	.42357				
EAS8		.76090			
EAS1		.71746			
EAS4		.59288			
EAS2		.54886			
EAS5		.50641			
EAS7		.45967			
EUCS9*		.43822*			
EAS3		**			
EAS6		**			
ATT5			.74333		
ATT4			.63713		
ATT2			.60892		
ATT3			.59552		
ATT1			.53607		
IMG2				.94129	
IMG1				.78487	
IMG3				.71110	
FREQ_USE					.73310
DAY_USE					.70590
USE_LVL					.58962
SOPH					.46679
NOSS_APP					**

Notes:
* Shares the same dimension in both *Ease of Use* and *EUCS*
** didn't load strongly (i. e., value less than 0.4)

Table 7.1 (Continued)

Item Code	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10
ENJ1	.73113				
ENJ2	.72343				
ENJ3	.66589				
VOLNT1		.78943			
VOLNT3		.74624			
VOLNT2		.71235			
EUCS-Content4			.66720		
EUCS-Content2			.65636		
EUCS-Content1			.59474		
EUCS-Content3			.52514		
EUCS-Accuracy1				.86964	
EUCS-Accuracy2				.79234	
EUCS-Format2					.87354
EUCS-Format1					.66278

Item Code	Factor 11	Factor 12	Factor 13
NBMC-MC1	.80992		
NBMC-MC2	.72106		
NBMC-NB2		.88538	
NBMC-NB1		.62658	
COMP2			.46547
COMP3			.40248
COMP1			**

Notes:
** didn't load strongly (i. e., value less than 0.4)

All expected factors emerged fairly "cleanly" except for *Normative Belief and Motivation to Comply (NBMC)* (factors 11 and 12) and the fourth component of *EUCS* which did not appear as a factor. The *NBMC* items did not emerge as a unidimensional factor but led to the extraction of two factors from NBMC:(1) *Normative Belief* (NB) (factor 12) and (2) *Motivation to Comply* (MC) (factor 11). The fourth sub-factor of *EUCS* (ease of use) did not load as a separate factor but instead loaded with *Ease of Use* factor (factor 2). *Compatibility* items loaded cleanly as a separate factor (factor 13). This is the result that Moore and Benbasat (1991) were expecting to find although in their results they found it to load with the *Relative Advantage* items as a single factor.

Interestingly, the first three of the four expected sub-factors of *EUCS* (content, accuracy, format, ease of use) emerged fairly "cleanly" under these predefined sub-factors or components by Doll and Torkzadeh (1988), but the fourth sub-factor (ease of use) didn't as it loaded with *Ease of Use* factor. It is logical that this last sub-factor of *EUCS* will behave like this since it is sharing the same dimension (i.e., easiness of use) with *Ease of Use* factor. This ease of use sub-factor has two items:

(i) EUCS9: spreadsheets were user friendly,

(ii) EUCS10: spreadsheets were easy to use.

EUCS10 and EAS8 are, in fact, the same item (common item between the *Ease of Use* and *EUCS* scales) and EUCS9 is clearly reflecting "ease of use", thus the two items deal with easiness of use which cause both items to load on *Ease of Use* factor.

Every single item was found to load on its expected 'target' construct and not on any other construct. However, two items of *Ease of Use* (EAS3 and EAS6) didn't load strongly (0.349 and 0.257 respectively). Looking at both items, EAS3 (using spreadsheets was **often frustrating**) and EAS6 (using spreadsheets required **a lot of mental efforts**) lend a hint that each of them may experience some sort of ill-conceptuality to fit with the other items of the *Ease of Use*, and not surprisingly neither item was among the original Davis' (1989) *Ease of Use* scale. One item of *Usage* NOSS-APP (number of spreadsheets applications used by respondent) didn't load strongly (0.289) which is consistent with what Lee (1986) found. One item of *Compatibility* COMP1 (using spreadsheets was compatible with all aspects of some tasks in my work) was also found not to load strongly (0.261), which is thought to be due to its non-suitable wording. All of these items were dropped later from their relevant scales, following the further reliability analysis.

The factor analysis results show that thirteen factors emerged with no major violation to the posited structure with 64.3% of the variance captured. As can be seen from the factor pattern matrix in Table 7.1, confirmatory factor analysis was successful in identifying thirteen-common factors and these has a fairly simple factor structure. No item loaded highly on more than one factor. Furthermore, all items remaining in the various scales loaded together on the "target" factor, with the lowest loading being 0.40 (Appendix C shows more details of factor analysis results).

Reliability Analysis

The Reliability Coefficient: Cronbach's Alpha (α)

One of the most commonly used reliability coefficients is Cronbach's alpha (α). After comparative study of groups of reliability estimates, Carmines and Zeller (1979) strongly recommend Cronbach's alpha, by saying, "by far the most popular of these reliability estimates is given by Cronbach's alpha". Alpha is based on the "internal consistency" of a scale. That is, it is based on the average correlation of items within a scale, if the items are standardized to a standard deviation of 1; or on the average covariance among items on a scale, if the items are not standardized.

The philosophy behind Cronbach's alpha is that we assume that the items on a scale are positively correlated with each other because they are measuring, to a certain extent, a common entity. If items are not positively correlated with each other, we have no reason to believe that they are correlated with other possible items we may have selected from a universal set of all possible items. In this case, we do not expect to see a positive relationship between this scale and other alternative scales designed to measure the same common entity (de Vaus, 1991).

Computing Cronbach's α

Cronbach's α can be computed using the following formula (Carmines and Zeller, 1979):

$$\alpha = k\,(\overline{\text{cov}} / \overline{\text{var}}) / [\,1 + (k-1)\,\overline{\text{cov}} / \overline{\text{var}}\,] \qquad (1)$$

where k is the number of items in the scale,
$\overline{\text{cov}}$ is the average covariance between items, and
$\overline{\text{var}}$ is the average variance of the items.

If the items are standardized to have the same variance, the formula can be simplified to

$$\alpha = k\,r / [\,1 + (k-1)\,r\,] \qquad (2)$$

where r is the average correlation between items.

Looking at equation (2), we can see that Cronbach's α depends on the average inter-item correlation (r) and the number of items in the scale or the length of the scale (k in the formula). For example, if the average correlation between items is 0.2 on a 10-item scale, α is 0.71. If the number of items is increased to 25, α is 0.86. A large reliability coefficient can be obtained even when the average inter-item correlation is small if the number of items on the scale is large enough. Thus, "as a general rule, multiple-item measures (scales) are much favored over single item measures" (Lewis-Beck, 1994). However, researchers and practitioners strive to achieve a high α value with a relatively short scale with items tapping the important information about the construct under consideration.

Interpreting Cronbach's Alpha

Cronbach's alpha has several interpretations. It can be viewed as the correlation between the scale in question and all other possible scales containing the same number of items, which could be constructed from a hypothetical universe of items that measure the characteristics of interest. In the *Relative Advantage* scale, for example, the eight questions which were actually selected for inclusion can be viewed as a sample from a universe of many possible items. Cronbach's alpha tells us how much correlation we expect between our scale and all other possible eight-item scales measuring the same thing.

Another interpretation of Cronbach's alpha is the squared correlation between the score a person obtains on a particular scale (the observed score) and the score he would have obtained if questioned on all of the possible items in the "universal set" (the true score).

Since alpha can be interpreted as a correlation coefficient, it ranges in value from 0 to 1. (Negative alpha values can occur when items are not positively correlated among themselves and the reliability model is violated). The higher the figure the more reliable the scale and, as a rule of thumb, alpha should be at least 0.7 before one can conclude the scale to be reliable (Nunnally, 1978). However, the accepted level of reliability depends on the purpose of the research project. For example, Nunnally (1978) argued that in early stages of research, reliabilities of 0.50 to 0.60 would suffice, and that "for basic research, it can be argued that increasing reliabilities beyond 0.80 is often wasteful of time and funds" (p. 245).

Test for Reliability

Equation (2) makes it clear that the value of alpha depends on the consistency of a person's response on an item compared to each other scale item (i. e., on the average inter-item correlation). Hence, the size of alpha is affected by the reliability of individual items. Thus, for each scale; to carry out a test for reliability for the items to be selected for the final scale, one needs to calculate the following figures:

- Corrected item-total correlations
- Alpha "if item deleted"

Both figures are generated by an SPSSx procedure. The output of this procedure (see for example Table 7.3) presents different item-total statistics in four columns. Two of them are the *corrected item-total correlations* and *alpha if item deleted* which are discussed below.

Corrected Item-Total Correlations

The figures in the column of *corrected item-total correlations* provide the internal consistency of each item related to the overall items in the scale. A low figure against an item in this column is an indication of that item being unreliable. By looking at low figures in this column unreliable items can be identified as candidates for deletion. The lower the figure the more unreliable the item is.

Alpha If Item Deleted

An increase in the value of alpha, and thus the scale's reliability, can be achieved by dropping unreliable items. To do this one would need to calculate what the alpha would be if a particular item was dropped. Since there is no absolute rule to decide whether an item should be deleted, one needs to see the effect on the scale alpha after its deletion. The column of *alpha if item deleted* provides such criterion. The higher the figure of *alpha if item deleted* against an item the greater the priority for such item to be deleted.

Reliability of Scales

For this study the target level of reliability is set in the 0.70 to 0.80 range. The factor analysis established above supports the construct validity of the ten scales. Having decided which items are worth including in the final scales (i. e., a consequence of construct validity), each scale reliability score is recalculated and rechecked for this sample using the above test for reliability. The next step is to test the internal consistency of each scale using the reliability coefficient alpha (α).

All scales achieved the minimum reliability scores targeted for this study ($\alpha \geq 0.70$). Table 7.2 below show each scale alpha (α) and the improvement in alpha if some item(s) is deleted.

Table 7.2: Each Scale's Alpha and Alpha Improvement if Item(s) Deleted

Scale Name	# of items	α	# of Item(s) Deleted	α if Item(s) Deleted	Scale Items	Scale final α
Relative Adv.	8	0.82	—	—	8	0.82
Ease of Use	8	0.76	2	0.80	6	0.80
Compatibility	3	0.67	1	0.70	2	0.70
Voluntariness	3	0.82	—	—	3	0.82
Enjoyment	3	0.85	—	—	3	0.85
Image	3	0.87	—	—	3	0.87
NBMC	4	0.79	—	—	4	0.79
Attitude	5	0.82	—	—	5	0.82
EUCS	10	0.81	—	—	10	0.81
Usage	5	0.74	1	0.79	4	0.79

As an example of how statistical procedures were taken to improve a scale reliability, the details of reliability testing procedures for the *Ease of Use* scale are shown below. Tables of detailed procedures for scales with improved alpha are provided in Appendix D.

Ease of Use Scale Reliability

From the factor analysis procedures carried out earlier, eight items loaded under Factor 2 named *Ease of Use*. Eight items emerged for the *Ease of Use* scale with alpha equal 0.76 with two items of low loading (EAS3 and EAS6). These two latter items were thus candidates for deletion in the next step. The item-total statistics reliability procedure was applied to check if the scale alpha (α) could be improved by deleting some item(s). Table 7.3 shows the *Ease of Use* scale item-total statistics, with the last two columns being *corrected item-total correlations* and *alpha if item deleted* respectively, each highlighting items being candidate for deletion.

Table 7.3: *Ease of Use* scale item-total statistics

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	**Alpha if Item Deleted**
EAS1	25.62	11.67	0.58	0.71
EAS2	25.74	11.41	0.50	0.73
EAS3	26.23	11.55	**0.37**	**0.76**
EAS4	26.13	11.37	0.57	0.71
EAS5	25.81	12.19	0.47	0.73
EAS6	26.33	12.80	**0.24**	**0.78**
EAS7	25.92	12.81	0.48	0.74
EAS8	25.65	12.17	0.63	0.71

N = 333 Number of Items = 8 Scale Alpha = 0.76

Both EAS3 and EAS6 show low item-total correlations (0.37 and 0.24). The *Ease of Use* scale alpha is 0.76 with 8 items. As EAS6 has the lowest item-total correlation, it has higher priority for deletion. If EAS6 is deleted the scale alpha will increase to 0.78 as per Table 7.3. Once EAS6 was deleted it still appeared advantageously to delete EAS3. After deleting EAS3 and EAS6, the same procedure was run again to produce the final scale item-total statistics which are shown below in Table 7.4.

Table 7.4: Final *Ease of Use* scale item-total statistics

Item	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Alpha if Item Deleted
EAS1	18.92	6.62	0.62	0.75
EAS2	19.03	6.54	0.50	0.78
EAS4	19.42	6.59	0.55	0.77
EAS5	19.11	6.96	0.52	0.77
EAS7	19.21	7.65	0.48	0.78
EAS8	18.94	7.02	0.69	0.74

N = 333 **Number of Items = 6** **Scale Alpha = 0.80**

By looking at the last column figures in Table 7.4, it is easy to see that there is no single item which if deleted will raise the scale's α as each entry is less than the current α (0.80). Hence it can be said that the *Ease of Use* scale has reached its maximum reliability that can be achieved with 6 items.

Initially, it was found that the alphas of three scales could be improved (see Table 7.2): *Ease of Use*, *Compatibility*, and *Usage*. The above process was applied to each of the three scales till no particular item seemed to be pulling alpha down, as deletion of any would lower the particular scale alpha. Meanwhile, preservation of the basic dimensions of the construct's conceptual meaning was kept in mind. In other words, some balanced tradeoff was maintained between the two conceptual and empirical complementary approaches mentioned earlier when theorising for reliable and valid scales.

Summary of Scales Reliability

In summary, the ten multi-item scales used in this study underwent several successive reliability testing treatments. The main four SPSSx reliability procedures were used repeatedly to produce the final ten scales.

Each scale underwent the same treatments applied to the *Ease of Use* scale described above as an example. A summary of the statistical information for the ten scales is given below in Table 7.5.

Table 7.5: Summary of Statistical Information for the final 10 Scales

Scale	Mean	Variance	Std. Dev.	Number of Items	Alpha
Relative Adv.	33.99	12.78	3.57	8	0.82
Ease of Use	22.93	9.54	3.09	6	0.80
Compatibility	7.73	1.41	1.19	2	0.70
Voluntariness	8.00	10.59	3.25	3	0.82
Enjoyment	10.49	4.59	2.14	3	0.85
Image	7.17	7.44	2.73	3	0.87
NBMC	14.17	8.76	2.96	4	0.79
Attitude	21.26	6.52	2.55	5	0.82
EUCS	39.07	21.22	4.61	10	0.81
Usage	16.58	12.84	3.58	4	0.79

As can be seen from Table 7.5, the lowest scale alpha is the *Compatibility* scale (0.70) which also has the fewest number of items. The scales' alphas range from this minimum of 0.70 up to 0.87 which proves to meet the study reliability target set earlier.

Besides the fact that the ten scales appear to have adequate reliability and validity, three of them (Relative Advantage, Ease of Use, and EUCS) have been widely served in the MIS field. Recently, these three scales have been undergoing successive rigorous replication, confirmatory analysis, test-retest, and repeated test-retest by researchers and practitioners in the field. Table 7.6 below shows some of these tests applied for the three scales.

Table 7.6: Previous Tests for Three Scales

	Scales / Type of Test		
Study Author(s)	Relative Advantage (Usefulness)	Ease of Use	E U C S
Torkzadeh and Doll (1991)	—	—	Test-Retest Reliability
Adams et al (1992)	Replication	Replication	—
Hendrickson et al (1993)	Test-Retest Reliability	Test-Retest Reliability	—
Segars et al (1993)	Confirmatory Factor Analysis	Confirmatory Factor Analysis	—
Hendrickson et al (1994)	—	—	Repeated Test-Retest
Doll et al (1994)	—	—	Confirmatory Factor Analysis
Subramanian (1994)	Replication.	Replication	

These studies provided rigorous tests for the above three scales adding further confidence to their adequate reliability and stable structure validity.

Summary

This chapter dealt with two measurements of crucial importance: the reliability and validity of scales. Both aspects were defined with some details felt necessary in the application of each aspect to the present research.

Validity of each of the ten scales used in this study was assessed using discriminant validity by applying confirmatory factor analysis (CFA). Factor loadings emerged with a simple factor structure and each scale items loaded fairly "cleanly" on the target scale. The data supports the construct and discriminant validity and reflects favourably on the factorial validity of the scales.

Reliability of each of the ten scales was assessed using Cronbach's alpha (α). The ten scales all proved to meet the reliability target for this study ($\alpha \geq 0.70$) with all alpha values falling in the range ($0.70 \leq \alpha \leq 0.87$). Thus it is fair to conclude that the ten scales are all reliable as they prove to show stability across the units of observation.

The results of the reliability and validity analysis gave an early positive indication of confidence in the research design as a whole. It meant in essence, that much greater confidence could be placed in the research results obtained by employing these scales. It, specifically, added further evidence of the suitability of using students in IT research as has been argued by Barrier and Davis (1993).

The next chapter is the beginning of the final data analysis where correlation and multiple regression analysis are applied to the research variables as per the research model in the research framework (Chapter 3).

Chapter 8

CORRELATION AND REGRESSION ANALYSIS

The objective of this chapter is to empirically test the hypothesized causal structure of the proposed research model described in Chapter 3. Employing correlation and multiple regression analysis, this chapter shows how the variables described were tested as contributing factors to spreadsheets acceptance (usage and satisfaction).

Variable Score

Each variable is measured by a set of questions (items) and for each question the respondents provide a score. The score is allocated to particular answers depending on how favourable the answer is to the variable item (e.g., attitude) being measured. To find the variable score for each respondent, the scores for each question are then added together to provide an overall score for the set of questions which constitute that variable (scale score). This scale score is taken to indicate a person's 'position' on the abstract dimension which the individual questions are intended to tap (de Vaus 1991). Singleton et al (1993) when addressing the issue of composite measures (indexes and scales), said: "how are separate measures combined or 'aggregated'? The simplest and most common procedure is just to add or take an average of the scores of the separate items; this is what we generally mean by an index" (p. 395).

Hence, for this study, to move from scale items to variable (construct) score, it was decided to take the average (mean) of the respondent's scores of the separate items that constitute that variable to obtain their scale score on the relevant variable. After aggregating for the variables, now it is time to employ correlation analysis which is discussed in the next step.

CORRELATION ANALYSIS

The main dependent variable of this research is that of *Usage* (made up of four scale items). All the other sixteen variables are considered independent variables. However, when applying multiple regressions, in the next section, some of these sixteen variables will be regressed (depend) on a subset of these variables called "regressors" (i. e., independent relative to the newly designated dependent or 'regressand' variable) chosen for a specific dependent variable according to the research model.

The first stage in testing the factors contributing to usage was to calculate correlation coefficients between all the independent variables and the four scale items which are indicators of the usage variable, and then to correlate all the independent variables with each other. This was expected to reveal many statistically significant correlations, as well as to provide further descriptive data prior to regression analysis such as diagnosis of multi-colinearity as recommended by Lewis-Beck (1980), Pedhazur (1982), and Glantz and Slinker (1990).

As the data had been noted to experience skewness, data underwent a transformation process. This involved using logarithms to remove skewness, and then normalising the data to have a mean of zero and standard deviation of one. Furthermore, as the data underwent this transformation process, from ordinal to interval level, product moment rather than rank correlations were calculated.

Table 8.1 shows product moment correlation coefficients for all the potential contributing factors (independent variables) with each of the four scale items constituting usage (dependent variable). It was found that each of the independent variables had a significant correlation with at least one of the four measures of the dependent variable. The first column of Table 8.1 shows the direction of the expected relationship based on prior research discussed earlier. The results from this study gave statistically significant support for all the expected relationships and in the expected direction.

Table 8.1: Contributing Factors and Four Measures of Spreadsheets Usage
Product Moment Correlation Coefficients

Expected Direction of Relationship		DAY_USE	FREQ_USE	SOPHIST.[1]	USE_LVL
	Beliefs About S/S[2]				
+	RELATIVE ADVANTAGE	.45**	.41**	.30**	.36**
+	COMPATIBILITY	.36**	.35**	.26**	.31**
+	EASE OF USE	.32**	.30**	.23**	.36**
+	ENJOYMENT	.30**	.41**	.22**	.30**
	Work Environment Beliefs				
-	VOLUNTARINESS	-.34**	-.31**	-.21**	-.16**
+	IMAGE	.22**	.17**	.11*	.07
+	NB_MC[3]	.22**	.31**	.05	.10
	Attitudinal Variables				
+	SUBJECTIVE NORMS	.31**	.29**	.12*	.09
+	ATTITUDE	.33**	.38**	.31**	.32**
+	SATISFACTION	.22**	.13*	.28**	.23**
	End User Background				
+	TRAINING	.21**	.25**	.21**	.23**
+	EUC_EXPERIENCE	.04	.07	.24**	.16**
+	SUPPORT	.20**	.24**	.22**	.20**
	S/S Rating				
+	S/S_RATING	.28**	.22**	.35**	.34**
	Demographic Variables				
-	COURSE	-.15**	-.16**	.05	-.08
-	GENDER	.03	-.09	-.08	-.04

* Significant at 5% or better ** Significant at 1% or better

Notes
1 Spreadsheets Application Sophistication level
2 S/S refers to Spreadsheets System Package
3 NB_MC refers to Normative Belief and Motivation to Comply

In this initial test of the research variables which consists of six major groups of variables (Chapter 3), each group of variables can be compared in relationship to the four scale items of usage. Findings are then discussed by group and by individual variable if necessary.

Beliefs about spreadsheets (Relative Advantage, Compatibility, Ease of Use, and Enjoyment) gave strong and significant positive correlations with all four scale items of usage.

Beliefs about the work environment gave mixed results. Voluntariness showed all significant but negative correlations. Image showed three significant and one non-significant positive correlations. NB_MC showed two significant and two non-significant positive correlations.

Subjective norms showed three significant and one non-significant positive correlations. Both satisfaction and attitude towards using spreadsheets showed strong and significant positive correlations with all four scale items of usage.

Both of training and support gave four strong and significant positive correlations. EUC_Experience gave two significant positive and two nonsignificant positive correlations.

Spreadsheets rating variable gave strong significant positive correlations with all the four scale items of usage. Course gave significant but negative correlations with daily use and frequency of use. This may be because of the different sorts of jobs taken by students from different courses, or it may be because of the different training in spreadsheets they have received while studying. There is no way this research can distinguish between these two possibilities.

Gender variable did not give any significant correlation with any of the four measures of spreadsheets usage. This finding indicates that gender might be of less contribution to the variability of spreadsheets usage.

MULTIPLE REGRESSION ANALYSIS

The second stage in testing the contributing factors was to conduct multiple regression analysis (MRA) in order to select those independent variables which statistically best explained the variability in the dependent variables. Thus multiple regression analysis was seen as a way of isolating the variables which seemed to make a significant impact on usage and satisfaction.

As said in the beginning of this chapter, it is highly recommended to diagnose the problem of multi-colinearity before using multiple regression analysis. If two independent variables are highly correlated, then it is possible that the association of one of these variables with the dependent variable could hide the importance of the other variable or the joint importance of the two variables. Under these circumstances, grouping the variables using factor analysis is more appropriate than testing each observed variable individually.

To overcome the potential problem of multi-colinearity, factor analysis was used to group many of the correlated observed scale items into independent latent variables prior to using regression analysis (see Chapter 7). The objective in using factor analysis was to identify some uncorrelated factors (latent variables) which themselves contained correlated (observed) variables (i.e., the scale items).

The pairwise correlations between the 16 independent (latent) variables are shown in Table 8.2. In total, 70 of the 120 correlations were statistically significant at the 5% level or better, demonstrating the expected high level of correlation between some of the independent variables. For example, users with strong positive beliefs about spreadsheets tended to have favourable attitude toward using the system, hence belief variables were correlated with attitude and satisfaction variables.

However, the factor analysis and pairwise correlations did not diagnose any symptoms of multi-colinearity such as correlation coefficients approaching 0.80. Indeed none of the correlation coefficients were greater than 0.61 indicating there are no cases of high multi-colinearity. In conclusion, proceeding to multiple regression analysis can be done without the threat of multi-colinearity.

Table 8.2: Product Moment Correlation Coefficients — Pairwise for all Variables

INDEPENDENT VARIABLES			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Beliefs About S/S	Rel_Adv	1	1.00																
	Comp.	2	.47	1.00															
	EOU	3	.31	.38	1.00														
	Enjoy.	4	.45	.49	.38	1.00													
Work Env. Beliefs	Volunt.	5	-.23	-.03	-.13	-.07	1.00												
	Image	6	.18	.20	.07	.29	-.06	1.00											
	NB_MC	7	.27	.16	.06	.29	-.32	.32	1.00										
Attitudinal Vars.	Subjnrm	8	.19	.20	.04	.18	-.25	.40	.54	1.00									
	Attitude	9	.46	.37	.34	.41	-.15	.12	.18	.18	1.00								
	Satisfy	10	.35	.31	.47	.35	-.02	.10	.04	.07	.31	1.00							
Background	Train.	11	.18	.08	.08	.13	-.24	.10	.21	.15	.07	.06	1.00						
	Exper.	12	.06	.14	.04	.04	.07	-.01	-.02	-.00	.18	.04	.01	1.00					
	Supprt	13	.21	.18	.07	.10	-.21	.06	.22	.14	.07	.16	.61	.15	1.00				
S/S Rating	Rating	14	.18	.20	.34	.15	-.08	.15	.07	.14	.17	.41	.16	.03	.24	1.00			
Demographics	Course	15	-.14	.05	-.17	-.09	.29	-.05	-.20	-.04	-.01	-.05	-.26	.36	-.18	-.03	1.00		
	Gender	16	-.07	-.05	-.01	-.01	-.10	.02	.00	-.08	-.02	.03	.09	-.13	.09	-.02	-.14	1.00	
DEPENDENT VARIABLE	Usage	17	.48	.41	.38	.38	-.34	.19	.22	.28	.42	.26	.27	.14	.27	.36	-.12	-.06	1.00

Note: A coefficient of 0.14 or greater is significant at the 1% level. The critical value for the 5% level is 0.11

Model Testing Process

The model developed in Chapter 3 and shown in Figure 3.4 will be tested according to the structural equation (causal) modelling paradigm defined by Duncan (1975) and Land (1973). Within this paradigm, the proposed model is "recursive" in that "no two variables are reciprocally related in such a way that each affects and depends on the other, and no variable 'feeds back' upon itself through any indirect concatenation of causal linkages, however circuitous" (Duncan 1975, p.25). Land (1973) shows that recursive models are identifiable and that ordinary least squares (OLS) regression applied to each equation provides optimal (minimum variance linear unbiased) parameter estimates.

Stepwise multiple regression analysis was carried out following factor and correlation analysis to test the hypothesized relationships between the variables laid down according to the research model in Chapter 3. The following type of regression equation was analysed using OLS:

$$\text{Response} = \beta_1 + \beta_2 \text{Var}_1 + \beta_3 \text{Var}_2 + \beta_4 \text{Var}_3 + \ldots + \beta_n \text{Var}_{n-1} + e$$

Where *response* is the dependent variable, each *Var* is an independent variable contributing to the dependent variable, beta (β) is the weight by which the effect of the independent variable on the dependent variable is measured, and *e* is an error result in the estimation of the response variable.

The results of each regression equation will be presented in a separate table. The R^2 value is a measure of the proportion of variability in the dependent (response) variable that is jointly explained by the independent (causal) variables. R^2 can range from 0.0 to 1.0, with higher values indicating a highly explanatory regression model. The beta (β) coefficients are standardised regression weights that serve as a measure of how much individual influence each independent variable has on the dependent variable. Beta coefficients can be interpreted as the number of units increase in the dependent variable resulting from a unit increase in the independent variable (where the variables are expressed in standardised units) while holding constant the other independent variables. Finally, the significance level is a measure of whether the magnitude of the effect of the independent variable (β) is significantly different from zero, with smaller values indicating greater significance. For an effect to be considered statistically significant, it is usually taken that significance level must be below .05 (Henkel, 1982). This implies that the probability of incorrectly concluding that beta is different from zero when it is actually equal to zero is .05.

In the model developed in Chapter 3, initially, one variable (usage) was purely a dependent variable, and 6 were purely independent variables (exogenous or predetermined with respect to all dependent variables), but 10 variables were seen both as dependent and independent in different parts of the model. These latter ten and usage are seen as dependent on other variables (endogenous) and eleven equations can be explored

In recursive models, the information in regard to causal ordering is specified in one direction by the proposed model. Such information is derived from the underlying theory which defines the causal ordering of the variables (Duncan 1975). Based on this, the TRA model of Fishbein and Ajzen (1975) and the TAM model of Davis (1986) prescribe the causal ordering for this study model as discussed in Chapter 3. Hence, each endogenous variable depends on all "prior" or "predetermined" variables and will only be regressed on the variables that precede (on the left of) it and in the same block level in the model.

In dealing with the problem of "causal inferences" between variables in the same block (level) in the model, one can never infer the causal ordering of two or more variables knowing only the values of the correlations (Kenny, 1979). Only if one's theory is comprehensive and robust enough to rule out all other alternatives would the inferred causal link be justified (Kenny, 1979 and Duncan, 1975). For this purpose, this study builds on Duncan's advice when implementing TRA and TAM, but if no support for an inferred causal link (relationship) is found in either of these or in any other past research, the direction of the causality will be argued on logical grounds (Hellevik, 1984 and Davis, 1985).

In order to predict the model of factors contributing to spreadsheets usage, only significant relationships between the model variables will be retained. If a relationship hypothesized to be insignificant is found significant, the corresponding independent variable shall be included in the regression. Such a finding would be suggestive of model misspecification, and to omit the variable in question may distort estimates of other relationships (Pindyck & Rubenfeld, 1981). Theoretical implications of such unexpected findings should be considered.

The initial testing for the proposed model revealed that the hypothesized model is generally confirmed by the data. One exception was found:

Compatibility and *Image* were shown to be external variables (block 1) as both were found not to be predicted by the other potential variables in the model while implementing the causal inferences rule within the frontier of recursive models (R^2=.06 and .05 respectively). Thus it was decided to move them from block 2 back to block 1 in the final model.

Thus the final model has only nine endogenous variables including usage and seven exogenous variables. Each one of the endogenous variables will be regressed on its antecedent variables as will be explained below.

While putting the structural equation modelling paradigm (discussed above) into operation, each of the nine endogenous variables will be regressed freely on those variables that precede it and in the same hierarchy. In other words, while not losing the proposed causal ordering hypothesized for the study model, hierarchical regression analysis or the hierarchical model is applied to predict each of the endogenous variables freely from its antecedent variables. This procedure will ensure the inclusion of those variables in the model that were hypothesized not to enter as predictors of the endogenous variable in question, which is often referred to as committing a specification error.

When two variables are found to be predicting each other (i.e., having bi-directional causal links), the rule set up above will be applied to determine only one qualified causal link to be accepted while rejecting the other. These steps are taken to keep the model recursive, in order to ensure model identification and remain applicable to OLS for providing optimal parameter estimates as mentioned earlier.

In the following each endogenous variable will be explored to identify its predicting variables which will be presented in the form of a regression equation. A summary table for R^2, independent variables emerged as predictors, β, t-statistics, and significance level is given for each equation. Comments on most of the relationships in the regression equation are included.

Usage

Usage as the main dependent variable of this research was predicted using all the remaining 16 variables. Hierarchical regression analysis was applied to predict Usage from 14 variables in blocks 1 and 2 besides the two hypothesized predicting variables Attitude (A) and Subjective Norms (SN) in block 3. Eight variables emerged as predictors of *Usage* and six variables were found not to do so and were thus dropped out the model. The eight independent variables that emerged as predictors of *Usage* are those appearing in the following regression equation:

$$\text{Usage} = \beta_1 + \beta_2 \text{ Attitude} + \beta_3 \text{ Subjective Norms} + \beta_4 \text{ Rel\_Adv} + \beta_5 \text{ Ease of Use} \\ + \beta_6 \text{ Voluntariness} + \beta_7 \text{ SS\_Rating} + \beta_8 \text{ Compatibility} + \beta_9 \text{ Training} + e_1$$

A and SN from block 3, Rel_Adv, EOU, and Vol from block 2, SS_Rating, Compt, and Training from block 1 emerged as the only eight predictors of Usage in the model. When regressing *Usage* (the behaviour) variable on all other (16) variables, *A* and *SN* persist to be significant confirming with the *TRA* model. *A* was stronger than *SN*, indeed the latter did not appear significant with Davis et al (1989) when comparing TRA and TAM as two theoretical models. This finding is considered a major finding confirming fully the TRA model where TAM failed to do so by not confirming the significance of the SN → Usage link.

To calculate the proportion of variance of Usage that A and SN account for, over and above (i.e., independently of) other variables, usage was regressed solely on A and SN. The result showed that both had significant, strong and positive effects on Usage (β was .384 and .216 significant at the .001 level for each respectively). Both together explained 23% of the variability of Usage which is half the variance explained by the hierachichal model.

From block 2, Relative Advantage (Rel-Adv) and Ease of Use (EOU) were found to contribute directly to Usage as they both had significant, strong and positive effects on it. Voluntariness also showed a strong but negative effect on Usage which indicates captive usage (Todd et al, 1992), that is usage tends to increase as less voluntary (i.e., compulsory) policy is applied in the organisation.

From block 1, Training, Compatibility and Spreadsheets System Rating (SS_Rating) all had significant, strong and positive effects on Usage. The eight predictor factors together explained about 47% of the variability of Usage. Table 8.3 shows the results of this regression analysis.

Table 8.3: Prediction of *Usage* from eight contributing factors

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
Usage	.466	Attitude	+.143	2.955	.003
		Subjective Norms	+.093	2.110	.035
		Rel_Adv	+.212	4.161	.000
		Ease of Use	+.134	2.814	.005
		Voluntariness	-.190	-4.271	.000
		Training	+.110	2.550	.011
		Compatibility	+.150	3.038	.003
		SS_Rating	+.172	3.870	.000

The variables that did not enter as predictors of Usage were Satisfaction, Enjoyment, Image, NBMC, Course, EUC_Experience, and Support. EUC_Experience was the first candidate to enter as its t statistics was 1.956 with significance of .051 which is almost significant. Although it was not that strong, Enjoyment with statistics of (1.517, .130) was the next insignificant candidate variable. The remaining variables were very weak in their effect on Usage.

End-User Computing Satisfaction (EUCS)

EUCS was thought to be better studied separately as alternative to the main dependent variable (usage) as researchers often use it as surrogate for user acceptance. EUCS was found not to be among the predictors of Usage. EUCS was found to be upstream (Figure 8.1) confirming what Doll and Torkzadeh (1991) theorized. The finding that EUCS was not a predictor of Usage, as mentioned above, fully corresponds to the EUCS instrument inventors views "we didn't measure satisfaction to predict behavior (e.g., usage)" (Doll and Torkzadeh 1991, p 6). It is unlikely that research attempts to link satisfaction to behaviour will be successful unless there is correspondence in target, action, context, and time between attitude and behavioural entities (Ajzen and Fishbein, 1977).

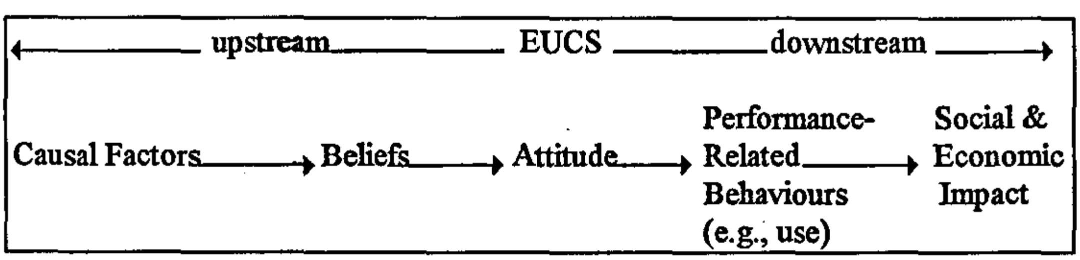

Figure 8.1 System to Value Chain (Doll & Torkzadeh 1991)

EUCS was regressed on all remaining variables including Usage. Only four variables emerged to be predictors of EUCS and these appear in the following regression equation:

$$EUCS = \beta_1 + \beta_2\,EOU + \beta_3\,Enjoyment + \beta_4\,Rel\_Adv + \beta_5\,SS\_Rating + e_2$$

EOU, Enjoyment and Rel_Adv from block 2, SS_Rating from block 1 emerged as the only four predictors of EUCS in the model. Ease of Use (EOU) had a significant, strong and positive effect on EUCS. SS_Rating also had a significant, strong and positive effect on EUCS. Rel_Adv and Enjoyment had smaller, positive but still significant effects on EUCS. The four predictor factors explained more than 33% of the variability of EUCS. Table 8.4 shows the results of this regression analysis.

Three of the four predictor variables of EUCS, namely, EOU, Enjoyment, and Rel_Adv are the same predictor variables of the Attitude variable which is discussed next. This finding is in support of the argument of Doll and Torkzadeh given above asserting that EUCS is to be placed upstream as an attitudinal variable in the system to value chain (see Figure 8.1).

Table 8.4: Prediction of *EUCS* from four independent variables

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
EUCS	.331	EOU	+.264	5.102	.000
		SS_Rating	+.274	5.630	.000
		Rel_Adv	+.142	2.769	.006
		Enjoyment	+.145	2.749	.006

Of those variables dropped out from the EUCS regression, because of their lack of statistical significance, Voluntariness was the first candidate variable with β (.084) and t statistics (1.788). This might point to how satisfaction with spreadsheets increases as voluntary usage increases. The next candidate was NBMC with β (-.077) and t statistics (-1.599). A positive relationship was expected but it was found to be negative. This might point to the effect of negative normative beliefs about spreadsheets in the workplace or the failure to comply with the norm of being satisfied towards using spreadsheets. The remaining variables were very weak in their effect on satisfaction.

Attitude

Attitude was regressed on all variables in blocks 1,2 and 3. Only four variables emerged to be predictors of Attitude and these appear in the following regression equation:

Attitude = β_1 +β_2 EOU + β_3 Enjoyment + β_4 Rel_Adv + β_5 EUC Experience + e_3

EOU, Enjoyment, and Rel_Adv from block 2 and EUC Experience from block 1 emerged as the only four predictors of Attitude in the model. Relative Advantage constitutes the main predictor of Attitude towards using spreadsheets as it had the most significant, strong and positive effect on attitude (β= 0.317). Ease of use and enjoyment had smaller positive yet significant effects on attitude. EUC Experience entered as the only external variable to affect Attitude directly as it had a small, positive yet significant effect. The four predictor factors explained more than 31% of the variability of attitude towards using spreadsheets. Table 8.5 shows the results of this regression analysis.

Table 8.5: Prediction of *Attitude* from four independent variables

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
Attitude	.312	Rel_Adv	+.317	6.100	.000
		EOU	+.174	3.467	.000
		Enjoyment	+.200	3.734	.000
		EUC Experience	+.137	2.967	.003

Of those variables dropped out from the Attitude regression, because of their lack of statistical significance, SN from block 3 was the first candidate variable with β (.082) and t statistics (1.746). This might point to how attitude towards using spreadsheets increases as subjective norms increase. The remaining variables were very weak in their effect on attitude towards using spreadsheets.

Subjective Norms

Subjective Norms (SN) was regressed on all variables in blocks 1,2 and 3. Only four variables emerged to be predictors of SN and these appear in the following regression equation:

$$SN = \beta_1 + \beta_2\,NB\_MC + \beta_3\,Image + \beta_4\,Voluntariness + \beta_5\,Course + e_4$$

NB_MC and Voluntariness from block 2 and Image and Course from block 1 emerged as the only four predictors of SN in the model. Normative belief and motivation to comply had a significant, strong and positive effect on subjective norms. Image had a smaller positive but still significant effect on subjective norms, whilst Voluntariness had a small negative, but significant effect. This negative relationship implies that as voluntariness decreases (compulsory rather than discretionary usage tends to be the norm) subjective norms increases towards using spreadsheets. Course had a small positive yet significant effect on SN which might indicate that business, as opposed to engineering and sciences, students had experienced a more compulsory usage norm or policy in the workplace. The four predictor factors explained more than 35% of the variability of subjective norms. Table 8.6 shows the results of this regression analysis.

Table 8.6: Prediction of *Subjective Norms* from four independent variables

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
Subjective Norms	.355	NB_MC	+.427	8.574	.000
		Image	+.253	5.375	.000
		Voluntariness	-.135	-2.770	.005
		Course	+.107	2.279	.023

Of those variables dropped out from the SN regression, because of their lack of statistical significance, Gender from block 1 was the variable with the highest β (-

.086) and t statistics (-1.910). This might reflect the point that females are experiencing less subjective norms towards using spreadsheets. Then came Compatibility and Spreadsheets System Rating (SS_Rating) with equal β (.078) and t statistics (1.700; 1.731) respectively. This might show that subjective norms towards using spreadsheets increases as spreadsheets better fit the task at hand and perceived by the user to have higher overall rating of spreadsheets system characteristics. The remaining variables were very weak in their effect on SN.

Relative Advantage (Rel_Adv)

Initially, Relative Advantage (Rel_Adv) was regressed on all variables in blocks 1 and 2, but after the first and second passes through the regression with all the variables involved, two of the block 2 variables were excluded. After this, only four variables emerged to be predictors of Rel_Adv and these appear in the following regression equation:

$$\text{Rel\_Adv} = \beta_1 + \beta_2 \text{ Compatibility} + \beta_3 \text{ Enjoyment} + \beta_4 \text{ Support} + \beta_5 \text{ Course} + e_5$$

Thus, Enjoyment from block 2 and Compatibility, Support, and Course from block 1 emerged as the only four predictors of Rel_Adv in the model. The Voluntariness → Rel_Adv and NBMC → Rel_Adv links were blocked as it was felt that the links in the opposite directions (Rel_Adv → Voluntariness and Rel_Adv → NBMC) were more logical. This might be argued as follows: when spreadsheets system is advantageously perceived by users, a voluntary usage policy might be more appropriate rather than a compulsory one and positive norms and higher tendency of motivation to comply are more likely in the workplace. These links are applicable when regressing for Voluntariness and NBMC as shown later.

Compatibility and Enjoyment had significant, strong and positive effects on Rel_Adv. This might be understood by saying that: the more compatible and enjoyable the spreadsheets system is, the more advantageously it will be perceived by the user. Support had a smaller positive but still significant effect on Rel_Adv. Course had a small, negative but significant effect on Rel_Adv which shows that business students are taking advantage of spreadsheets more than their counterparts in engineering and sciences. The four predictor factors explained more than 31% of the variability of Relative Advantage. Table 8.7 shows the results of this regression analysis.

Table 8.7: Prediction of *Relative Advantage* from four independent variables

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
Rel_Adv	.312	Compatibility	+.326	6.074	.000
		Enjoyment	+.265	4.996	.000
		Support	+.110	2.308	.021
		Course	-.115	-2.440	.015

Of those variables dropped out from the Rel_Adv regression, because of their lack of statistical significance, Gender from block 1 was the variable with the highest β (-.083) and t statistics (-1.785). This might reflect the point that females hold a lower perception of the relative advantage of spreadsheets. Then came Ease of Use (EOU) with β (.072) and t statistics (1.387). EOU has been found to be a significant antecedent of Rel_Adv by Davis (1993) and Davis et al (1989) but found here to affect Rel_Adv indirectly through Enjoyment as will be shown later. The remaining variables were very weak in their effect on Rel_Adv.

Ease of Use (EOU)

Initially, EOU was regressed on all variables in blocks 1 and 2, but after the first pass through the regression with all the variables involved, two of the block 2 variables were excluded. After this, only three variables emerged to be predictors of EOU and these appear in the following regression equation:

$$EOU = \beta_1 + \beta_2 \text{ Compatibility} + \beta_3 \text{ SS\_Rating} + \beta_4 \text{ Course} + e_6$$

Thus, Compatibility, SS_Rating, and Course from block 1 emerged as the only three predictors of EOU in the model. Following Davis et al (1992), Enjoyment → EOU link was blocked and the EOU → Enjoyment link was accepted. The NB_MC → EOU link was also blocked as it was felt that the link in the opposite direction (EOU → NB_MC) was more logical even though this link was not significant when regressing for NB_MC as will be shown below.

Compatibility had a significant, very strong and positive effect on Ease of Use. Spreadsheets system Rating (SS_Rating) also had a significant, strong and positive effect on EOU. Course had a significant and strong but negative effect on EOU. This negative relationship might reflect the fact that spreadsheets applications used by engineering and sciences students are more complex than the applications used by the business students. These three predictor factors explained about 25% of the variability of Ease of Use. Table 8.8 shows the results of this regression analysis.

Table 8.8: Prediction of *Ease of Use* from three independent variables

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
Ease of Use	.246	Compatibility	+.332	6.791	.000
		SS_Rating	+.267	5.463	.000
		Course	-.182	-3.793	.000

Of those variables dropped out from the EOU regression, because of their lack of statistical significance, Support from block 1 was the variable with the highest β of (-.095) and t statistics (-1.874). This might reflect the point that support is more necessary when spreadsheets applications are more complex. The remaining variables were very weak in their effect on EOU.

Enjoyment

Enjoyment was regressed on all variables in blocks 1 and 2, but after the first pass through the regression with all the variables involved, two of the block 2 variables were excluded. After this, only three variables emerged to be predictors of Enjoyment and these appear in the following regression equation:

Enjoyment = $\beta_1 + \beta_2$ Compatibility + β_3 EOU + β_4 Image + e_7

Thus, Ease of Use from block 2 and Compatibility and Image from block 1 emerged as the only three predictors of Enjoyment in the model. The Rel_Adv → Enjoyment link was blocked and the link in the opposite direction (Enjoyment → Rel_Adv) was accepted as stated above when Relative Advantage was regressed. Also, the NB_MC → Enjoyment link was blocked and the link in the opposite direction (Enjoyment → NB_MC) was accepted and this was reasoned as follows: the more enjoyable the use of spreadsheets system is perceived, the stronger normative belief and motivation to comply towards using in the workplace will be. This relationship is applicable when regressing for NB_MC as shown later.

Compatibility had a very strong, significant positive effect on Enjoyment. Ease of use (EOU) and Image had smaller, positive yet significant effects on Enjoyment. The three predictor factors explained about 33% of the variability of Enjoyment. Table 8.9 shows the results of this regression analysis.

Table 8.9: Prediction of *Enjoyment* from three independent variables

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
Enjoyment	.325	Compatibility	+.366	7.350	.000
		E O U	+.226	4.632	.000
		Image	+.205	4.434	.000

Of those variables dropped out from the Enjoyment regression, because of their lack of statistical significance, Training from block 1 was the variable with the highest β (.061) and t statistics (1.333). This might reflect the point that training might be more demanded for more enjoyable use of spreadsheets. Then came Course with β (-.061) and t statistics (-1.322) which might reflect that business, as opposed to engineering an sciences, students had more enjoyment while using spreadsheets. This might be related to the higher complexity of the spreadsheets applications used by engineering and sciences students. The remaining variables were very weak in their effect on Enjoyment.

Voluntariness

Voluntariness was regressed on all variables in blocks 1 and 2. Only three variables emerged to be predictors of Voluntariness and these appear in the following regression equation:

$$\text{Voluntariness} = \beta_1 + \beta_2\,\text{NB\_MC} + \beta_3\,\text{Course} + \beta_4\,\text{Training} + \beta_5\,\text{Rel-Adv} + e_8$$

Normative Belief & Motivation to Comply and Relative Advantage from block 2 and Course and Training from block 1 emerged as the only four predictors of Enjoyment in the model.

Normative belief and motivation to comply (NB_MC) had a strong, significant but negative effect on Voluntariness. This negative relationship might reflect that: the stronger the normative belief and motivation to comply towards using spreadsheets, the more likely of enforcing a compulsory usage policy (i.e., Voluntariness tends to decreases). Course had a significant and strong positive effect on Voluntariness which might implies that engineering and sciences students have experienced more discretionary (voluntary) usage as opposed to business students.

Both Training and Rel_Adv had strong, significant but negative effects of Voluntariness. This might reflect the fact that as spreadsheets are perceived more advantageously and more investment on spreadsheeting training, the less likely of voluntariness usage (i.e., compulsory policy is more probable). The four predictor factors explained more than 18% of the variability of Voluntariness. Table 8.11 shows the results of this regression analysis.

Table 8.11: Prediction of *Voluntariness* from four independent variables

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
Voluntariness	.183	NB_MC	- .217	- 4.089	.000
		Course	+ .199	3.801	.000
		Training	- .115	- 2.175	.030
		Rel-Adv	- .124	- 2.371	.018

Of those variables dropped out from the Voluntariness regression, because of their lack of statistical significance, Enjoyment from block 2 was about to enter the regression with β (.108) and t statistics (1.912 at .056). This might reflect the point that when using spreadsheets is enjoyable, discretionary (voluntary) usage policy is more applicable. Then came Gender and Compatibility with β (-.072, .080) and t statistics (-1.419, 1.395) respectively. The remaining variables were very weak in their effect on Voluntariness.

Normative Belief and Motivation to Comply (NB_MC)

Initially, NB_MC was regressed on all variables in blocks 1 and 2, but after the first pass through the regression with all the variables involved, one of the block 2 variables was excluded. After this, only three variables emerged to be predictors of NB_MC and these appear in the following regression equation:

$$\text{NB\_MC} = \beta_1 + \beta_2\,\text{Image} + \beta_3\,\text{Enjoyment} + \beta_4\,\text{Support} + \beta_5\,\text{Course.} + \beta_6\,\text{Rel\_Adv} + e_9$$

Thus, Enjoyment and Relative Advantage from block 2 and Image, Support and Course from block 1 emerged as the only five predictors of NB_MC in the model. Both links, Enjoyment → NB_MC and Rel_Adv → NB_MC, were accepted here as the opposite of each link was blocked as stated earlier. The Vol → NB_MC link was blocked and the link in the opposite direction (NB_MC → Vol) was accepted. This negative relationship was reasoned as follows: the stronger normative belief and motivation to comply towards using spreadsheets in the workplace the less likely of a voluntary (discretionary) policy of spreadsheets usage will be applied.

Image, Enjoyment, Support, and Rel_Adv had significant, strong and positive effects on NB_MC. This could be reasoned to the fact that, the more prestigious, enjoyable, advantgeous the use of spreadsheets was perceived, and more support was provided in the workplace the stronger the normative belief towards using and complying with this norm. Course had a significant, strong but negative effect on NB_MC and this might point that engineering and sciences students experienced lower normative belief towards using spreadsheets as opposed to that of the business students. The five predictor factors explained about 21% of the variability of NB_MC. Table 8.13 shows the results of this regression analysis.

Table 8.13: Prediction of *NB_MC* from five independent variables

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
NB_MC	.206	Image	+.243	4.696	.000
		Enjoyment	+.138	2.438	.015
		Support	+.139	2.724	.006
		Course	-.136	-2.703	.007
		Rel_Adv	+.115	2.042	.041

Of those variables dropped out from the NB_MC regression, because of their lack of statistical significance, EOU from block 2 was the variable with the highest β (-.098) and t statistics (-1.808, .071). This might reflect the point that the more difficult to use spreadsheets is perceived in the workplace, the stronger the normative belief towards using spreadsheets and more compliment with this norm is needed to convince users. The remaining variables were very weak in their effect on NB_MC.

Summary

To summarise the correlation analysis, the data gave very good results in general. Spreadsheets usage was found to be significantly associated with all proposed contributing factors except that with gender. Only a negative association was detected with voluntariness indicating that captive usage increases as voluntariness decreases, in other words; usage tends to decreases for discretionary usage policy.

Regarding the multiple regression analysis, *Gender* did not appear to have any contribution to any variable in the proposed model. Thus it was decided to omit this variable from the final model. In general, most of the hypothesized relationships were confirmed by the data. Thus the results gave very good support to prior studies of factors contributing to user acceptance of information technology. Table 8.14 below summarizes the regression results.

This study succeeded to support TRA by proving the prediction of behaviour (Usage) from attitude (A) and subjective norms (SN). It also proved to be in full match with TRA according to the general structure of the study variables causal ordering. More specifically, external variables came to be at the far left followed by belief variables which in turn followed by A and SN which both lead to behaviour. The study violated TRA in terms of the paths linking variables from block 1 and 2 to the target behaviour (Usage) and from block 1 to A and SN.

The study supports TAM in proving that relative advantage (usefulness) is the most important variable influencing attitude towards IT acceptance in addition to the direct path from relative advantage to usage. It also supports that other related beliefs about IT (enjoyment and ease of use) have direct influence on A and/or usage in addition to the indirect influence through relative advantage as TAM postulated. The study supports the distribution of antecedent variables hypothesized to influence each of A and SN.

Thus it is fair to conclude that this chapter results gave a very good support to prior studies of factors contributing to user acceptance of information technology which implemented TRA and TAM as a base theory in studying this phenomena.

Table 8.14: Summary of regression results

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
Usage	.466	Attitude	+.143	2.955	.003
		Subjective Norms	+.093	2.110	.035
		Rel_Adv	+.212	4.161	.000
		Ease of Use	+.134	2.814	.005
		Voluntariness	-.190	-4.271	.000
		Training	+.110	2.550	.011
		Compatibility	+.150	3.038	.003
		SS_Rating	+.172	3.870	.000
EUCS	.331	EOU	+.264	5.102	.000
		SS_Rating	+.274	5.630	.000
		Rel_Adv	+.142	2.769	.006
		Enjoyment	+.145	2.749	.006
Attitude	.312	Rel_Adv	+.317	6.100	.000
		EOU	+.174	3.467	.000
		Enjoyment	+.200	3.734	.000
		EUC Experience	+.137	2.967	.003
Subjective Norms	.355	NB_MC	+.427	8.574	.000
		Image	+.253	5.375	.000
		Voluntariness	-.135	- 2.770	.005
		Course	+.107	2.279	.023

Table 8.14: Summary of regression results (Continued)

Dependent Variable	R^2	Independent Variables	Effect (β)	t Stat.	Sig. Lvl.
Rel_Adv	.312	Compatibility	+.326	6.074	.000
		Enjoyment	+.265	4.996	.000
		Support	+.110	2.308	.021
		Course	-.115	-2.440	.015
Ease of Use	.246	Compatibility	+.332	6.791	.000
		SS_Rating	+.267	5.463	.000
		Course	-.182	-3.793	.000
Enjoyment	.325	Compatibility	+.366	7.350	.000
		E O U	+.226	4.632	.000
		Image	+.205	4.434	.000
Voluntariness	.183	NB_MC	-.217	-4.089	.000
		Course	+.199	3.801	.000
		Training	-.115	-2.175	.030
		Rel-Adv	-.124	-2.371	.018
NB_MC	.206	Image	+.243	4.696	.000
		Enjoyment	+.138	2.438	.015
		Support	+.139	2.724	.006
		Course	-.136	-2.703	.007
		Rel_Adv	+.115	2.042	.041

Chapter 9

DETERMINANTS OF USAGE AND EUCS

The major thrust of this study was to investigate the factors contributing to (i.e., the determinants of) spreadsheets usage and end-user computing satisfaction (EUCS). Both of these major goals are explored in this chapter through path analysis. The analysis attempted to answer two questions; (1) what factors determine usage and EUCS, and (2) is EUCS a good surrogate of usage?

What Factors Determine Usage?

The research by Davis (1986 and 1993), Davis et al (1989), Thompson et al (1991), Davis et al (1992) and Igbaria (1990 and 1993) all looked at determinants of usage of microcomputers and related software. The base model used and causal order of the variables tested in these studies are summarised in Table 9.1. It can be seen that a number of variables have been investigated as causes of usage. Some of these expected relationships were confirmed, for example, usefulness is a major determinant of usage. However, others were not, in particular, subjective norms was found not to be related to IT acceptance (usage) (Davis, 1986 and Davis et al, 1989).

These studies provided a number of variables which could be reexamined in this study of spreadsheets software. Their relationship with spreadsheets usage and EUCS could be investigated. Typically, the above studies used different theoretical base models but used almost the same measures of usage. This study adopted TRA and TAM as theoretical base models and used the same measures of usage as discussed in Chapters 3 and 5. Four measures of Usage were adopted and EUCS was measured using ten Likert statements from the instrument devised by Doll and Torkzadeh (1988) (Chapter 5).

Table 9.1 : Prior studies of the determinants of Usage

Study	Base Model	Variables Examined		
		External	Intervening	Dependent
Davis 1986	TRA	System (e-mail, text editor)	EOU, Usefulness, Quality, Enjoyment	Usage
Davis et al 1989	TRA vs TAM	System (word processor)	EOU, Usefulness	Usage
Igbaria 1990	TRA	Demographics, Training, Computer Experience, Support, Task Uncertainty	Computer Anxiety	Task Performed, Usage, EUCS, and Perceived Effectiveness
Thompson et al 1991	Triandis' Model	EOU, Usefulness, Enjoyment, Support	—	Usage
Davis et al 1992	TRA & TAM	System (word processor)	EOU, Usefulness, Task, Output Quality, Enjoyment	Usage
Davis 1993	TRA & TAM	System (e-mail, text editor)	EOU, Usefulness	Usage
Igbaria 1993	TRA & TAM	Demographics, Training, Computer Experience, Support	Computer Anxiety, Usefulness	Usage

A Structural Equation (Causal) Model of Spreadsheets Usage and EUCS

The above literature review identified likely important variables in the study of Usage. However, a remarkable weakness of such studies has been their reliance on a single external variable (with the exception of Igbaria 1990 and 1993) with just a few intervening variables. Furthermore, almost no normative variables about the workplace and only a few variables dealing with IT characteristics were investigated. To overcome this problem, additional essential variables taken from Moore and Benbasat (1991) and Igbaria (1990,1993) were incorporated in a single model in this study.

Apart from the basic constructs of NBMC, SN, A, and behaviour (usage) provided by the base theory (TRA), several variables were considered as antecedents to these conceptual constructs. Two important factors, which were seen to influence usage, were investigated by these studies as intervening variables (except Thompson et al 1991). Ease of use (EOU) and usefulness (Relative Advantage) were viewed as belief variables and major determinants of attitude towards using and usage.

Enjoyment (or fun) was considered an important influential variable and a determinant of usage (Thompson et al 1991; Davis et al 1992; Igbaria et al 1994). Compatibility was thought to be of considerable effect on attitude and usage, thus it was investigated in this research whereas none of the prior studies did.

Davis (1986) and Davis et al (1989) investigated subjective norms in the workplace as an antecedent to behavioural intention (BI) and usage but they found no significant relationships. Despite the ambiguity of determinant variables that can be specified to this area, two variables were thought to be of influential power in this regard: Voluntariness and Image; these were investigated as determinants of subjective norms which in turn determines usage.

A review of the relevant literature suggests that user acceptance of new technology (e.g., spreadsheets software) is affected directly and/or indirectly by external variables. Following Igbaria (1990 and 1993) several external variables such as individual characteristics including demographic variables (gender, course), EUC experience, and organisational characteristics (support and training) were identified. System characteristics was also included as an external variable (Igbaria et al 1990).

The proposed causal model of the current study (Figure 3.4) is reproduced here in Figure 9.1, and depicts the above mentioned variables and represents a number of hypotheses. Each arrow implies a hypothesized significant influence between variables connected. For example, taking the variable attitude, the model implies that compatibility, ease of use, enjoyment, and relative advantage of spreadsheets influence attitude. In turn, attitude influences the use of spreadsheets.

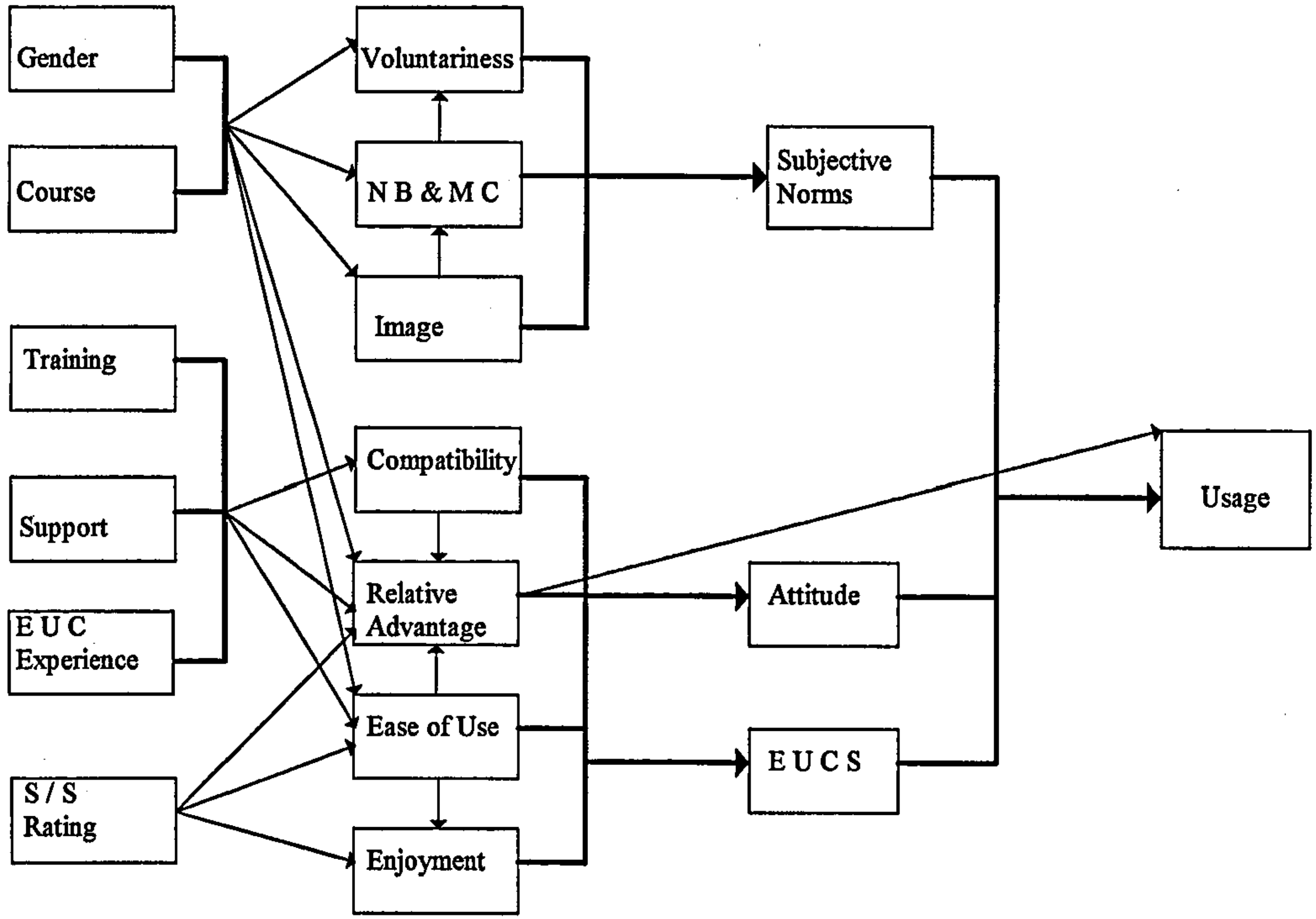

Figure 9.1 — A Proposed Model for Spreadsheets Usage and EUC Satisfaction (EUCS)

PATH ANALYSIS

Overview

Path analysis is concerned with estimating the magnitude of the linkages (relationships) between variables and using these estimates to provide information about the underlying causal processes (Asher 1983, p30). It is a technique that has been developed to test such a set of relationships.

These estimates (path coefficients) can be obtained by a number of different procedures, the simplest way of which is to employ ordinary regression techniques. Often path analysis uses the outcome of regression analysis, mainly, R^2 and β values. R^2 is used to calculate the residual path coefficients and βs represent the magnitude of the main path coefficients as will be discussed below.

To obtain estimates of the main path coefficients, one simply regresses each endogenous variable on those variables that directly impinge upon it, with the assumption that the residual variable in a structural equation be uncorrelated with the explanatory variables in that equation (Asher 1983; Loehlin 1987).

The residual path coefficients can also be demonstrated by ordinary regression analysis since they have a direct regression interpretation. The general form of a residual path coefficient is $\sqrt{1-R^2}$ where R^2 is commonly referred as the proportion of explained variance. Since the standardised variables have a variance of 1, the general expression $1-R^2$ is simply the proportion of unexplained variance. Therefore, the residual path coefficient is simply the square root of the unexplained variation in the dependent variable in question.

Path analysis is superior to ordinary regression analysis since it allows us to move beyond the estimation of direct effects, the basic output of regression. Rather, path analysis allows one to examine the causal processes underlying the observed relationships and to estimate the relative importance of alternative paths of influence. The model testing permitted by path analysis further encourages a more explicitly causal approach in the search for explanations of the phenomena under investigation (Asher 1983, p. 36-37).

Path Diagram

The path diagram, although not essential for numerical analysis, is a useful tool for displaying graphically the pattern of causal relations among a set of variables (Pedhazur 1982). In path analysis, as Li (1986) put it, "a diagram will be most helpful, if not indispensable, to specify the exact nature of a proposed structure, according to which subsequent analysis is to be made. Hence, a path analysis and its corresponding path diagram always go hand in hand."

The proposed model for this study was reproduced in Figure 9.1 above which represents a number of hypotheses. The major factors and their hypothesised influences are depicted where each arrow implies a hypothesized significant influence. This model underwent rigororous correlation and multiple regression analysis as discussed in Chapter 8 resulting in a 3-stage path model for Usage and 2-stage path model for EUCS. Both models are depicted in Figure 9.2.

Figure 9.2 represents the structural equation (causal) model of contributing factors to spreadsheets Usage and EUCS, each treated as a latent variable. In this causal model a number of causal links are represented. Each arrow implies a significant influence between variables connected. Thus the causal structure which emerged from multiple regression analysis (in Chapter 8) is depicted here (Figure 9.2 below) in the form of a path diagram which is to be utilised for the purpose of path analysis. The presentation of path analysis in this chapter is limited to recursive models as decided in the previous chapter. This means that the causal flow is unidirectional and, in other words, at a given point in time a variable can not be both a cause and an effect of another variable.

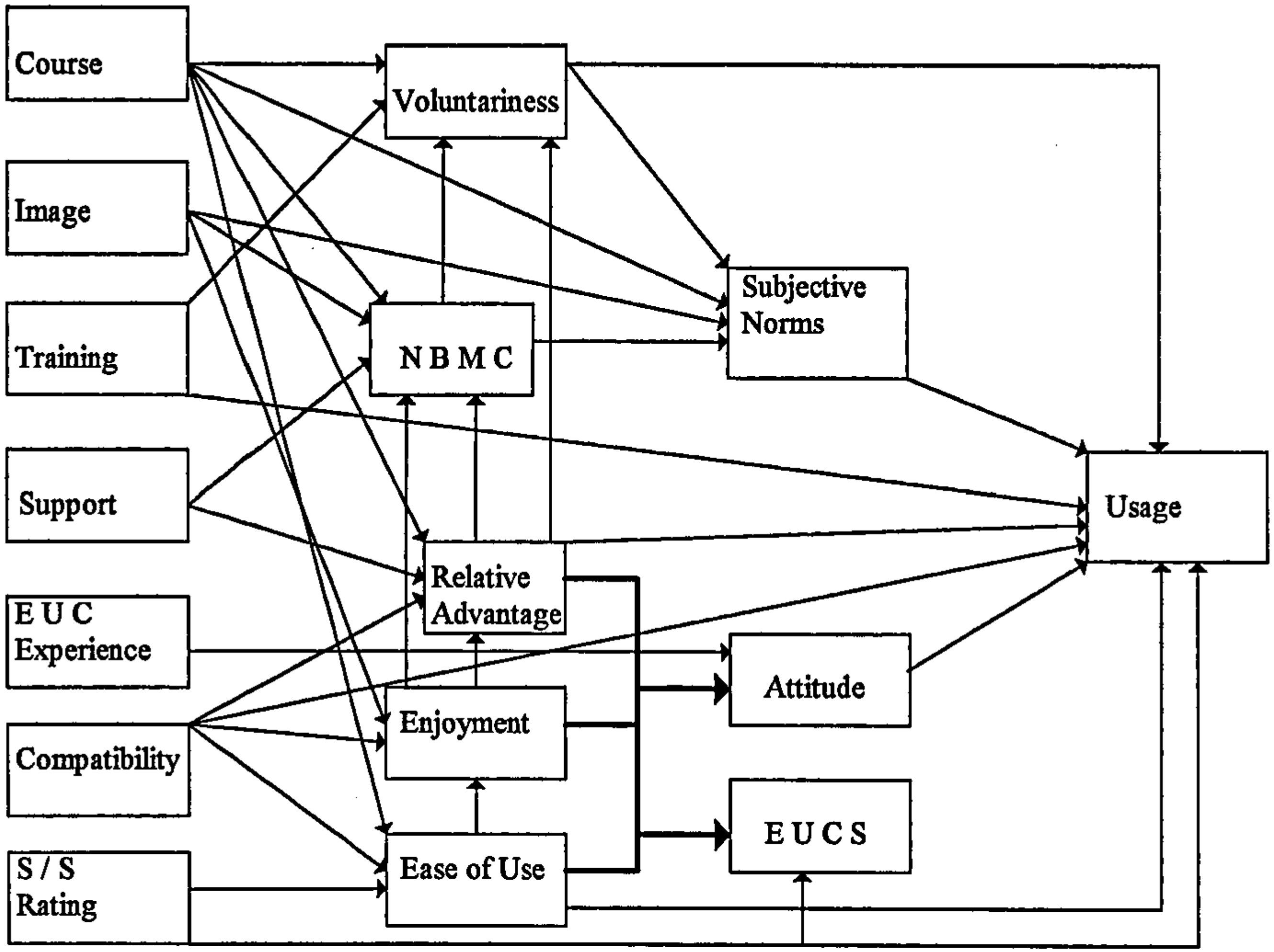

Figure 9.2— Contributing Factors to Spreadsheets Usage and EUCS: A Structural Equation Model

The aim of path analysis is to provide quantitative estimates of the causal connections between sets of variables. The connections proceed in one direction and are viewed as making up distinct paths. These ideas can best be explained with reference to the central feature of a path analysis —the path diagram.

The path diagram makes explicit the likely causal connections between variables. Figure 9.3 is the path diagram for Usage and EUCS which is derived from Figure 9.2. The arrows indicate the derived causal connections between variables. The model moves from left to right implying causal priority to those variables closer to the left.

Each p denotes a causal path and hence a path coefficient that will need to be computed. The model indicates that Training has a direct effect on Usage ($p_{16,3}$). However, indirect effects of Training are also found: Training affects Voluntariness ($p_{12,3}$) which in turn affects Usage ($p_{16,12}$) and ($p_{13,12}$) affects Subjective Norms which in turn affects Usage ($p_{16,13}$).

In addition, each endogenous variable has further arrows directed to them from outside the nexus of variables. These refer to the amount of unexplained variance for each variable by its predicting variables. Thus the arrow to Enjoyment (.822), for example, refers to the amount of variance in Enjoyment that is not accounted for by EOU, Image, and Compatibility (as the only 3 predictors of Enjoyment).

In order to provide estimates of each of the postulated paths, path coefficients are computed. A path coefficient is a standardized regression coefficient. The path coefficients are computed by using the nine *structural equations*, that is equations which stipulate the structure of hypothesized relationships in a model. In the case of Figure 9.3, the nine structural equations required are the nine multiple regression equations discussed earlier in Chapter 8.

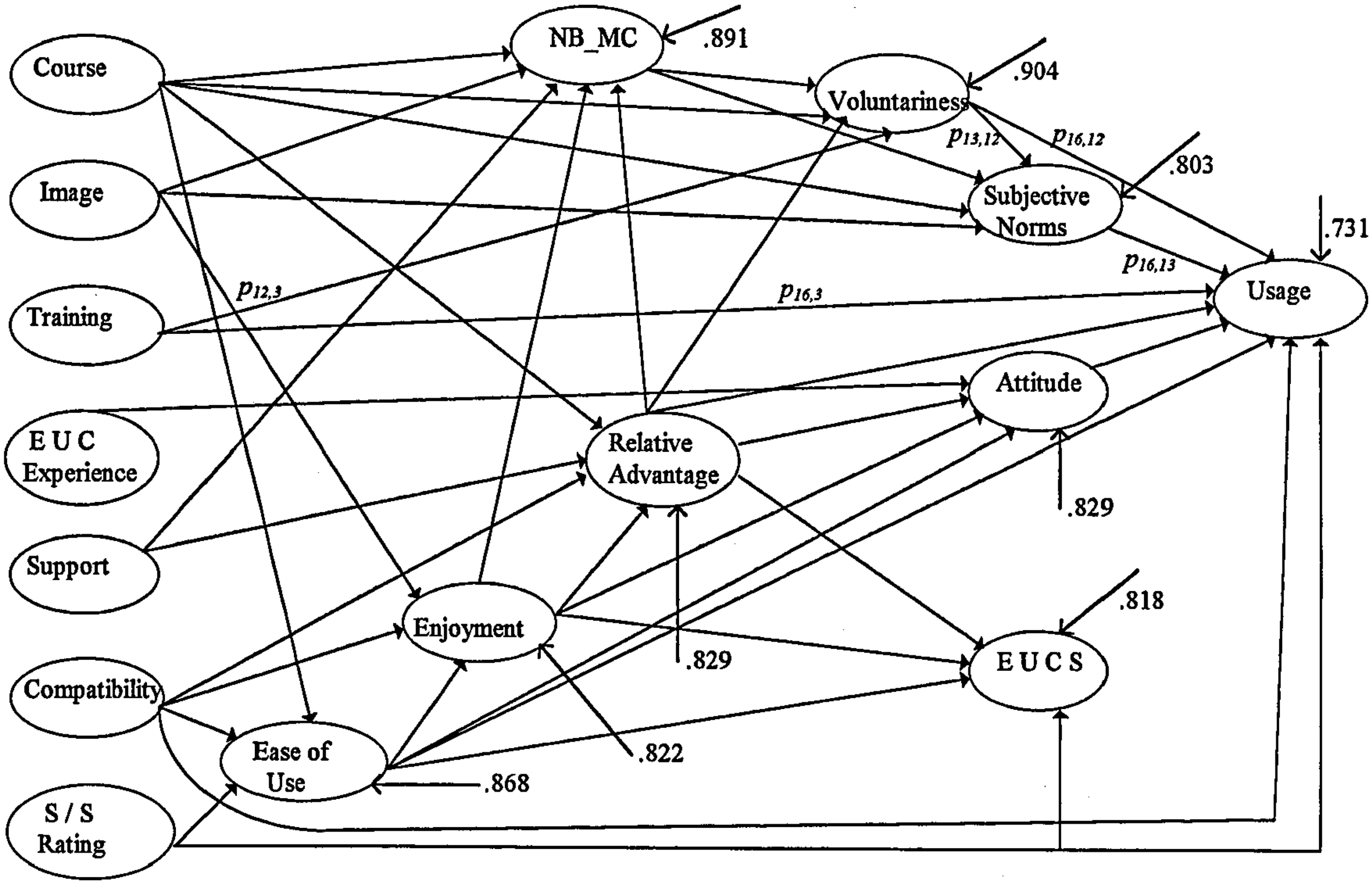

Figure 9.3 : Path diagram for Usage and EUCS

Total Effect of Contributing Factors

One of the main advantages of path analysis is that it enables one to measure the direct and indirect effects that one variable has on another. Many researchers recommend calculating the overall impact of each variable in the causal model (Ross 1975; Pedhazur 1982; Hellevik 1984; Li 1986; Bryman and Cramer 1990). In the previous chapter multiple regression analysis was applied for the endogenous variables in the model. When it is desired to determine the expected change in an endogenous variable that is associated with a unit change in one of its causes, it is the total effect (or the effect coefficient) of the cause that should be used for this purpose. Path analysis is used in this chapter to determine the total effect of each independent variable on their related dependent variables.

The direct effect can be identified as the magnitude of the path coefficient (β) along the path connecting the cause and the effect variables. An indirect effect represents those effects interpreted by the intervening variables; it is the product of the path coefficients (βs) along an indirect route from the cause to the effect via tracing arrows in the headed direction only. When more than one indirect path exists, the total indirect effect is their sum (Ross 1975, Li 1986).

Total effect is calculated as the sum of direct effect and indirect effect(s) of an independent variable on its related dependent variable. Thus the following equation is used for calculating the total effect of a causal variable on the effect variable:

$$\text{Total Effect} = \text{Direct Effect} + \text{Indirect Effect(s)}.$$

The Calculation of Total and Indirect Effects

For simple models, it is fairly easy to calculate the indirect effect(s) (IE) by multiplying the βs along the traced route from the causal variable to the effect variable; by adding all IEs to the direct effect (DE) it yields the total effect (TE). In complex models (such as this study model), however, this method of calculating IEs becomes quite cumbersome and hence error-prone (Pedhazur 1982). A more sophisticated yet simpler method using matrix algebra is more commendable if not indispensable as tracing of routes becomes more tedious and complicated. This method, among other different methods, was developed by Fox (1980).

The basic matrices of TE and IE's are identified as follow:

D_{yx} the matrix of direct effect of exogenous variables on endogenous variables;

D_{yy} the matrix of direct effects of endogenous variables on endogenous variables;

Several other marices and equations needed during the calculation procedures are defined as:

I is an identity matrix whose dimensions are the same as D_{yy} ;

$C = - D_{yx}$;

$B = I - D_{yy}$;

$E_{yx} = - B^{-1} C$ where E_{yx} is the matrix of the total effects (TEs) of the exogenous variables on the endogenous variables and B^{-1} is the inverse of the matrix B;

$I_{yx} = E_{yx} - D_{yx}$ where I_{yx} is the matrix of indirect effects (IEs) of the exogenous variables on the endogenous variables;

$E_{yy} = B^{-1} - I$ where E_{yy} is the matrix of total effects (TEs) of endogenous variables on endogenous variables.

$I_{yy} = E_{yy} - D_{yy}$ where I_{yy} is the matrix of indirect effecs (IEs) of endogenous variables on endogenous variables.

For the causal model employed in the current study (Figure 9.3), the following computer programme statements (lines of codes) were developed:

```
TITLE ===========       PATH ANALYSIS    ===============
MATRIX.
COMPUTE DYX = {-.115,0,0,0,.110,.326,0;
               -.182,0,0,0,0,.332,.267;
                .199,0,-.115,0,0,0,0;
                0,.205,0,0,0,.366,0;
               -.136,.243,0,0,.139,0,0;
                .107,.253,0,0,0,0,0;
                0,0,0,.137,0,0,0;
                0,0,.110,0,0,.150,.172}.
COMPUTE DYY = {0,0,0,.265,0,0,0,0;
               0,0,0,0,0,0,0,0;
              -.124,0,0,0,-.217,0,0,0;
               0,.226,0,0,0,0,0,0;
              .115,0,0,.138,0,0,0,0;
              0,0,-.135,0,.427,0,0,0;
             .317,.174,0,.200,0,0,0,0;
             .212,.134,-.190,0,0,.093,.143,0}.
COMPUTE C= -1 * DYX.
COMPUTE I = IDENT(8).
COMPUTE B = I - DYY.
COMPUTE INVB = INV(B).
COMPUTE EYX = -1 * INVB * C.
COMPUTE EYY = B-1 - I.
COMPUTE IYX = EYX - DYX.
COMPUTE IYY = EYY - DYY.
PRINT DYX/TITLE "DYX: DIRECT EFFECTS OF X ---> Y".
PRINT DYY/TITLE "DYY: EFFECTS OF Y ---> Y".
PRINT EYX/TITLE "EYX: TOTAL EFFECTS OF X ===> Y".
PRINT EYY/TITLE "EYY: TOTAL EFFECTS OF Y ===> Y".
PRINT IYX/TITLE "IYX: INDIRECT EFFECTS OF X ---> Y".
PRINT IYY/TITLE "IYY: INDIRECT EFFECTS OF Y ---> Y".
END MATRIX.
EXECUTE.
```

The output of the above programme is shown below:

Table 9.2: Direct Effects of X → Y (Matrix D_{yx})

X →	Course	Image	Training	EUC_Exp	Support	Compat	S/S Rating
Rel_Adv	-.115	.000	.000	.000	.110	.326	.000
E O U	-.182	.000	.000	.000	.000	.332	.267
Volunt	.199	.000	-.115	.000	.000	.000	.000
Enjoy	.000	.205	.000	.000	.000	.366	.000
NB_MC	-.136	.243	.000	.000	.139	.000	.000
S N	.107	.253	.000	.000	.000	.000	.000
Attitude	.000	.000	.000	.137	.000	.000	.000
Usage	.000	.000	.110	.000	.000	.150	.172

Table 9.3: Indirect Effects of X →Y (Matrix I_{yx})

X →	Course	Image	Training	EUC_Exp	Support	Compat	S/S_Rating
Rel_Adv	-.011	.054	.000	.000	.000	.117	.016
EOU	.000	.000	.000	.000	.000	.000	.000
Volunt	.050	-.067	.000	.000	-.047	-.079	-.004
Enjoy	-.041	.000	.000	.000	.000	.075	.060
NB_MC	-.020	.035	.000	.000	.013	.112	.011
SN	-.100	.128	.016	.000	.071	.058	.005
Attitude	-.080	.058	.000	.000	.035	.286	.064
Usage	-.110	.068	.023	.020	.044	.200	.050

Table 9.4: Total Effects of X ⇒ Y (Matrix D_{yx})

X →	Course	Image	Training	EUC_Exp	Support	Compat	S/S_Rating
Rel_Adv	-.126	.054	.000	.000	.110	.443	.016
EOU	-.182	.000	.000	.000	.000	.332	.267
Volunt	.249	-.067	-.115	.000	-.047	-.079	-.004
Enjoy	-.041	.205	.000	.000	.000	.441	.060
NB_MC	-.156	.278	.000	.000	.152	.112	.011
SN	.007	.381	.016	.000	.071	.058	.005
Attitude	-.080	.058	.000	.137	.035	.286	.064
Usage	-.110	.068	.133	.020	.044	.350	.222

Table 9.5: Direct Effects of Y → Y (Matrix D_{yy})

Y → Y	Rel_Adv	EOU	Volunt	Enjoy	NB_MC	SN	Attitude
Rel_Adv	.000	.000	.000	.265	.000	.000	.000
EOU	.000	.000	.000	.000	.000	.000	.000
Volunt	-.124	.000	.000	.000	-.217	.000	.000
Enjoy	.000	.226	.000	.000	.000	.000	.000
NB_MC	.115	.000	.000	.138	.000	.000	.000
SN	.000	.000	-.135	.000	.427	.000	.000
Attitude	.317	.174	.000	.200	.000	.000	.000
Usage	.212	.134	-.190	.000	.000	.093	.143

Table 9.6: Indirect Effects of Y → Y (Matrix I_{yy})

Y → Y	Rel_Adv	EOU	Volunt	Enjoy	NB_MC	SN	Attitude
Rel_Adv	.000	.060	.000	.000	.000	.000	.000
EOU	.000	.000	.000	.000	.000	.000	.000
Volunt	-.025	-.016	.000	-.069	.000	.000	.000
Enjoy	.000	.000	.000	.000	.000	.000	.000
NB_MC	.000	.038	.000	.030	.000	.000	.000
SN	.069	.018	.000	.081	.029	.000	.000
Attitude	.000	.064	.000	.084	.000	.000	.000
Usage	.080	.051	-.013	.118	.084	.000	.000

Table 9.7: Total Effects of Y ⇒ Y (Matrix E_{yy})

Y → Y	Rel_Adv	EOU	Volunt	Enjoy	NB_MC	SN	Attitude
Rel_Adv	.000	.060	.000	.265	.000	.000	.000
EOU	.000	.000	.000	.000	.000	.000	.000
Volunt	-.149	-.016	.000	-.069	-.217	.000	.000
Enjoy	.000	.226	.000	.000	.000	.000	.000
NB_MC	.115	.038	.000	.168	.000	.000	.000
SN	.069	.018	-.135	.081	.456	.000	.000
Attitude	.317	.238	.000	.284	.000	.000	.000
Usage	.292	.185	-.203	.118	.084	.093	.143

Similarly, the End-User Computing Satisfaction (EUCS) contributing factors' total and indirect effects (TEs and IEs) were calculated applying Fox's method. The results of these effects are shown in Tables 9.8 — 9.13 below.

Table 9.8: Direct Effects of X $\rightarrow$ Y (Matrix D_{yx})

X $\rightarrow$	Course	Image	Support	Compat.	S/S_Rating
Rel_Adv	-.115	.000	.110	.326	.000
E O U	-.182	.000	.000	.332	.267
Enjoyment	.000	.205	.000	.366	.000
E U C S	.000	.000	.000	.000	.274

Table 9.9: Indirect Effects of X $\rightarrow$ Y (Matrix I_{yx})

X $\rightarrow$	Course	Image	Support	Compat.	S/S_Rating
Rel_Adv	-.011	.054	.000	.117	.016
E O U	.000	.000	.000	.000	.000
Enjoyment	-.041	.000	.000	.075	.060
E U C S	-.072	.037	.016	.214	.082

Table 9.10: Total Effects of X ===> Y (Matrix E_{yx})

X $\rightarrow$	Course	Image	Support	Compat.	S/S_Rating
Rel_Adv	-.126	.054	.110	.443	.016
E O U	-.182	.000	.000	.332	.267
Enjoyment	-.041	.205	.000	.441	.060
E U C S	-.072	.037	.016	.214	.356

Table 9.11: Direct Effects of Y $\rightarrow$ Y (Matrix D_{yy})

Y $\rightarrow$ Y	Rel_Adv	E O U	Enjoyment	E U C S
Rel_Adv	.000	.000	.265	.000
E O U	.000	.000	.000	.000
Enjoyment	.000	.226	.000	.000
E U C S	.142	.264	.145	.000

Table 9.12: Indirect Effects of $Y \rightarrow Y$ (Matrix I_{yy})

$Y \rightarrow Y$	Rel_Adv	E O U	Enjoyment	E U C S
Rel_Adv	.000	.060	.000	.000
E O U	.000	.000	.000	.000
Enjoyment	.000	.000	.000	.000
E U C S	.000	.041	.038	.000

Table 9.13: Total Effects of $Y \Longrightarrow Y$ (Matrix E_{yy})

$Y \rightarrow Y$	Rel_Adv	E O U	Enjoyment	E U C S
Rel_Adv	.000	.060	.265	.000
E O U	.000	.000	.000	.000
Enjoyment	.000	.226	.000	.000
E U C S	.142	.305	.183	.000

Relative Comparison of Determinants

Regression analysis was conducted to estimate path coefficients. Following the advice of Asher (1983), standardised scores were used for all variables (mean 0, standard deviation 1). Hence, when standardised variables are used in recursive models, the path coefficients are actually standardised regression coefficients (β's). A major advantage of β's over b's (the unstandardised regression coefficients) is that they are scale-free and can therefore be compared across different variables.

When it is desired to determine the expected change in an endogenous variable that is associated with a unit change in one of its causes, it is the **total effect** of the cause that should be used for this purpose. It is important to note that using only the direct effect of a variable for such interpretation may be misleading because, being a β, it is calculated while controlling for all variables that affect a given endogenous variable. That is, the variables that mediate the effect of a causal variable on an endogenous variable are also controlled when the direct effect of the former on the latter is calculated (Pedhazur 1982).

Thus for Usage, by looking at Table 9.4 and Table 9.7, it is quite clear that among the exogenous (external) determinants of Usage, Compatibility achieved the strongest effect (.350), followed by Spreadsheets System Rating (.222), and Training (.133). From endogenous variables, Relative Advantage showed the strongest effect (.292) followed by Voluntariness (- .203), and Ease of Use (.185).

Regarding EUCS, by looking at Table 9.10 and Table 9.13, it can be seen that among exogenous (external) determinants of EUCS, Spreadsheets System Rating achieved the strongest effect (.356), followed by Compatibility (.214). Ease of Use was the endogenous variable with the strongest effect (.305) followed by Enjoyment (.183), and finally Relative Advantage (.142) from among endogenous variables.

Can EUCS be a Good Surrogate Measure of Usage?

As well as investigating determinants of Usage and EUCS, this survey data also provided an opportunity to explore the correlation between EUCS and Usage. The motivation behind such analysis being that several MIS researchers point out if end-users understand the tools and have the motivation to use them, then the full potential of end-user computing (EUC) will be realized (Cheney et al 1986, Sein et al 1987). Moreover, greater computer related skills, education and experience have been found to positively affect one's use of corporate information system resources (Nelson and Cheney 1987). Further, Bailey and Pearson (1983) argued that utilization is directly connected to the user community's sense of satisfaction with those services.

However, the relationship between user satisfaction and system usage is still under debate (Torkzadeh and Dwyer 1994). Delone and McLean (1992) argue that usage and user satisfaction affect each other and that there are reciprocal influences. As this study is investigating both Usage and EUCS as potential measures of user acceptance (as a form of MIS success), a brief review of the literature on measures of MIS success followed by the results of the correlation analysis are reported and discussed below.

Measures of MIS Success

Ives and Olson (1984), in a review of studies using a measure of Information System (IS) success, identified four types of measure of MIS success:

⇒ System quality — an attempt to measure organisational impact

⇒ System acceptance — particularly system use

⇒ Perceived quality / user information satisfaction (UIS)

⇒ Changes in user behaviour / attitudes

They concluded that UIS was the most commonly used dependent variable. The work by Doll and Torkzadeh (1988) promoted the use of an adapted, validated version of the previous UIS instruments developed to be more specific to end-user computing (EUCS). Srinivasan (1985) questioned the assumption that behavioural measures and perceived measures were the same. He found little correlation between measures of "actual use and perceived system worth" (p 247). Doll and Torkzadeh (1991), the developers of the EUCS instrument applied in this study, have stated that "we didn't measure satisfaction to predict behaviour (e.g., usage)" (p 6). Ajzen and Fishbein (1977) raised doubts that research attempts to link satisfaction to behaviour will be successful unless there is correspondence in target, action, context, and time between attitude and behavioural entities.

Correlations between EUCS and Usage

Product moment correlations between EUCS and the four individual indicators which together make up Usage are shown in Table 9.14. In general all the correlations are strong and positive indicating that EUCS and Usage are significantly and positively correlated. In Chapter 8 neither EUCS nor Usage was among the predictors of any of these two concepts.

Furthermore, by looking at the determinants of EUCS and Usage discussed above (and summarised below in Table 9.15). It can be seen that, in addition to discrepancy in types and numbers of determinants of each construct, common determinants of each have different total effects.

EUCS is not determined by external variables other than S/S rating. It is also not related to normative variables in the workplace. EUCS may be more properly described as an attitudinal (perceptual) construct which is not related to objective measures like Usage.

Table 9.14: Correlations Between EUCS and Four Measures of Usage

	Measures of Usage			
	Daily use	Frequency of use	Sophistication	Usage level
EUCS	.22**	.13*	.28**	.23**

* significant at 5% level or better
** significant at 1% level or better

Table 9.15: Determinants of Usage and EUCS and their Total Effects

Potential Determinant	Usage (Total Effect)	E U C S (Total Effect)
Compatibility	.350	.214
Relative Advantage	.292	.142
S/S Rating	.222	.356
Voluntariness	- .203	—
Ease of Use	.185	.305
Enjoyment	.183	.118
Subjective Norms	.093	—
Attitude	.143	—
Training	.133	—
Course	- .110	- .072

An implication of such findings is that researchers should differentiate between the objective measures of Usage and perceptual measures of EUCS. Srinivasan (1985) showed that behavioural measures and perceptual measures of IS success were measuring different concepts. This latest data suggest that predictors of a perceptual measures such as user satisfaction are different to predictors of objective measures such as usage. Correlations reported earlier showed that Usage measures were positively correlated with user satisfaction. If usage, as a measure of system acceptance, is the ultimate goal of investment in information technology then satisfaction is an important agent in the process, especially, when system usage is discretionary (Baroudi et al, 1986). The policy applied in the workplace (voluntary vs compulsory) plays an important role to achieve such goal. Adams et al (1992) found that captive usage (i.e., amount of usage due to compulsory policy) blurred user acceptance of IT and can not be viewed as if it was only harnessed by user satisfaction.

Although they were found to be positively correlated, the analysis of the study results in total do not support the view that EUCS can be used as a surrogate for Usage. Instead this research lends weight to the approach of employing both EUCS and Usage as complements to each other in the measurement of user system acceptance.

Chapter 10

LISREL MODELLING

This chapter is a presentation of the LISREL structural modelling technique. An overview of the technique is given at the beginning, followed by its application in the present study, and concluding with some strengths and weaknesses of the method.

Overview

LISREL stands for Linear Structural RELationships and, strictly speaking, is a computer programme for covariance structure analysis (Diamantopoulos 1994) for estimating the unknown coefficients in a set of linear structural equations and for testing the overall fit of the proposed model to the data. The LISREL programme "has played such a vital role in the acceptance and application of the covariance structure model that such models are often referred to as 'LISREL models'" (Long 1983, p. 12). In the literature, covariance structure analysis is also commonly referred to as "structural modelling with unobservables", "linear structural relations", "latent variable equation systems", "linear structural equation modelling" and, perhaps most often, as "causal modelling with unobservables".

LISREL modelling is a "second generation" multivariate technique combining methodological contributions from two disciplines: the factor analysis model from psychometric theory and the structural equations model typically associated with econometrics (Fornell 1983). Its aim is to explain the structure or pattern among a set of latent (unobserved or theoretical) variables, each measured by one or more manifest (observed or empirical) and typically fallible indicators (Diamantopoulos 1994).

Thus there are two parts to a covariance structure model: firstly, the *measurement* part which describes how each of the latent variables is operationalized via the manifest variables and provides information about the validities and reliabilities of the latter; and secondly, the *structural* part which specifies the relationships between the latent variables themselves (reflecting substantive hypotheses based on theoretical considerations) and the amount of unexplained variance.

In employing causal structural equation modelling, the objective is to derive a measurement model linking indicator variables to latent variables, and a particular cause—effect pattern of relationships among latent variables (Saris and Stronkhorst 1984, Cuttance and Ecob 1987, Bollen 1989). It is to determine whether the covariances obtained among the indicator variables (calculated from the data) are consistent with the research model. In other words, the objective is to minimise the difference in the covariance generated from the path coefficients with the original covariance matrix generated from the data.

LISREL Model for Usage

The LISREL model assumes a causal structure among a set of latent variables. These latent variables appear as underlying causes of the observed variables. The model consists of two sets of equations: firstly, the *measurement model* equations which specifies how the latent variables (or hypothetical constructs) are measured in terms of the observed variables, and how these are used to describe the measurement properties (validities and reliabilities) of the observed variables (Byrne 1989). And secondly, the *structural equation model* which specifies the causal relationships among the latent variables and is used to describe the causal effects.

The Usage model which emerged from the regression analysis in Chapter 8 is taken here as the LISREL proposed model in this study. The measurement model and the structural equation model to be analysed by LISREL are described subsequently.

The Measurement Model

The measurement model is concerned with reliability and construct validity; also it determines the extent to which the operationalization of a construct actually measures what it purports to measure. It specifies the relationships between unobserved (latent) variables and observed (manifest) indicator variables. As reliability and validity analysis for the measurement model of this study were conducted in Chapter 7, it will not be discussed in detail here. Two separate equations describe this model:

(1) $Y = \Lambda_y \eta + \varepsilon$ where

- Y is a $p \times 1$ vector of measures of endogenous variables
- Λ_y is a $p \times m$ matrix of coefficients (loadings) of y on latent (unobserved) endogenous variables (η's)
- ε is a $p \times 1$ vector of errors of measurement of y.

(2) $X = \Lambda_x \xi + \delta$ where

- X is a $q \times 1$ vector of measures of exogenous variables
- Λ_x is a $q \times n$ matrix of coefficients (loadings) of x on unobserved exogenous variables (ξ's)
- δ is a $q \times 1$ vector of errors of measurements of x.

In the Usage model there were n=7 (7 ξs) and m=8 (8 ηs). Each of these ξs and ηs is measured by a number of indicators (q xs and p ys). Explicitly, the following is a list of ξs and ηs and the number of indicators used to measure each of them in the study questionnaire:

Latent Variable (endogenous)	Number of Indicators (ys)
η_1 (Ease of Use)	8
η_2 (Enjoyment)	3
η_3 (Relative Advantage)	8
η_4 (NB_MC)	4
η_5 (Voluntariness)	3
η_6 (Subjective Norms)	1
η_7 (Attitude)	5
η_8 (Usage)	4

Total number of indicators for endogenous variables, p = 36

Latent Variable (exogenous)	Number of Indicators (xs)
ξ_1 (Course)	1
ξ_2 (Image)	3
ξ_3 (Training)	9
ξ_4 (EUC Experience)	8
ξ_5 (Support)	13
ξ_6 (Compatibility)	2
ξ_7 (S/S Rating)	1

Total number of indicators for exogenous variables, $q = 37$

There are eight matrices that need to be calculated when processing any LISREL model. These are the Λ_x and Λ_y already shown together with the following six:

Θ_ε is a pxp matrix of covariances among errors of the ys.
Θ_δ is a qxq matrix of covariances among errors of the xs.
Ψ is a mxm matrix of covariances among errors of the concepts of ηs.
Φ is a nxn matrix of covariances among the concepts of ξs.
B is mxm matrix of βs (structural coefficients as will be explained later).
Γ is mxn matrix of γs (structural coefficients as will be explained later).

The PC version of the LISREL 7 programme developed by Joreskog and Sorbom (1989) was used in this study. The study measurement model (in Chapter 5) with such large values of p,q,m, and n (36, 37, 8, and 7 respectively) is considered too large to be analysed and processed using a PC version of LISREL. Default value for maximum number of CPU-seconds that might be allowed for the PC version are 172,800 seconds (2 days) (Joreskog and Sorbom 1989, p 72). Thus due to lack of computational capacity it was decided to reduce the measurement model to be able to cope with the capacity available.

To reduce the measurement model, most variables measured with multiple items (indicators) were reduced to have only one or two indicators. Relative Advantage, for example, was measured originally by 8 indicators but only 1 indicator is used here for this concept. Torkzadeh and Dwyer (1994) implement this strategy through single-item global scales which have strong correlations with their corresponding multiple-item scales. The item "Overall, I found using spreadsheets to be advantageous in my work" was the single-item global scale which has the strongest correlations with the other 7 items constituting the eight-item scale for Rel_Adv. This was the only item of Rel_Adv used in the present LISREL model.

Likewise, Ease of Use was measured by a single-item global scale which has the strongest correlations with the other 7 items constituting the original eight-item scale for this concept: "Overall, I believe that spreadsheets system was easy to use". A single item was also used to measure Voluntariness, Image, Enjoyment, Normative Believe, and Motivation to Comply. Two items were used to measure Attitude, four items were used to measure EUCS and four items for Usage.

Each of the above mentioned latent variables was measured using an instrument or a scale. The application of the single-item global scale to them was fairly easy as stated above. For those latent variables which do not have typical (formal) instruments or scales, the single-item global scale strategy is not applicable. The conventional variable score strategy (Chapter 8) was used to reduce the number of items for each variable. An aggregate or a composite item was used to represent the multiple items that measure each of them. Each latent variable was assigned a single indicator valued with the mean of the multiple items used to measure that variable. These variables were Training, Support, and EUC Experience.

With these restrictions, the LISREL measurement model for Usage is presented in Table 10.1 and depicted in Figure 10.1 below.

Table 10.1: Usage Measurement Model

Construct (Latent)/ Indicator Variable	Observed Variable	Standardised Loading (λ)	r^2
Course (ξ_1)	x_1	0.949	0.900
Image (ξ_2)	x_2	0.949	0.900
Training (ξ_3)	x_3	0.949	0.900
EUC_Exp (ξ_4)	x_4	0.949	0.900
Support (ξ_5)	x_5	0.949	0.900
Compatibility (ξ_6)	x_6	0.948	0.899
SS_Rating (ξ_7)	x_7	0.949	0.900
EOU (η_1)	y_1	0.949	0.901
Enjoy (η_2)	y_2	0.949	0.901
Rel_Adv (η_3)	y_3	0.949	0.900
NBMC (η_4)			
NB	y_4	0.636	0.405
MC	y_5	0.462	0.213

Table 10.1: Usage Measurement Model (Continued)

Construct (Latent)/ Indicator Variable	Observed Variable	Standardised Loading (λ)	r^2
VOLNTRY (η_5)	y_6	0.949	0.900
SN (η_6)	y_7	0.949	0.900
ATTITUD (η_7)			
ATT1	y_8	0.625	0.391
ATT2	y_9	0.581	0.337
USAGE (η_8)			
Day-Use	y_{10}	0.829	0.688
Freq_Use	y_{11}	0.828	0.686
Use_Levl	y_{12}	0.649	0.422
Sophist.	y_{13}	0.542	0.294

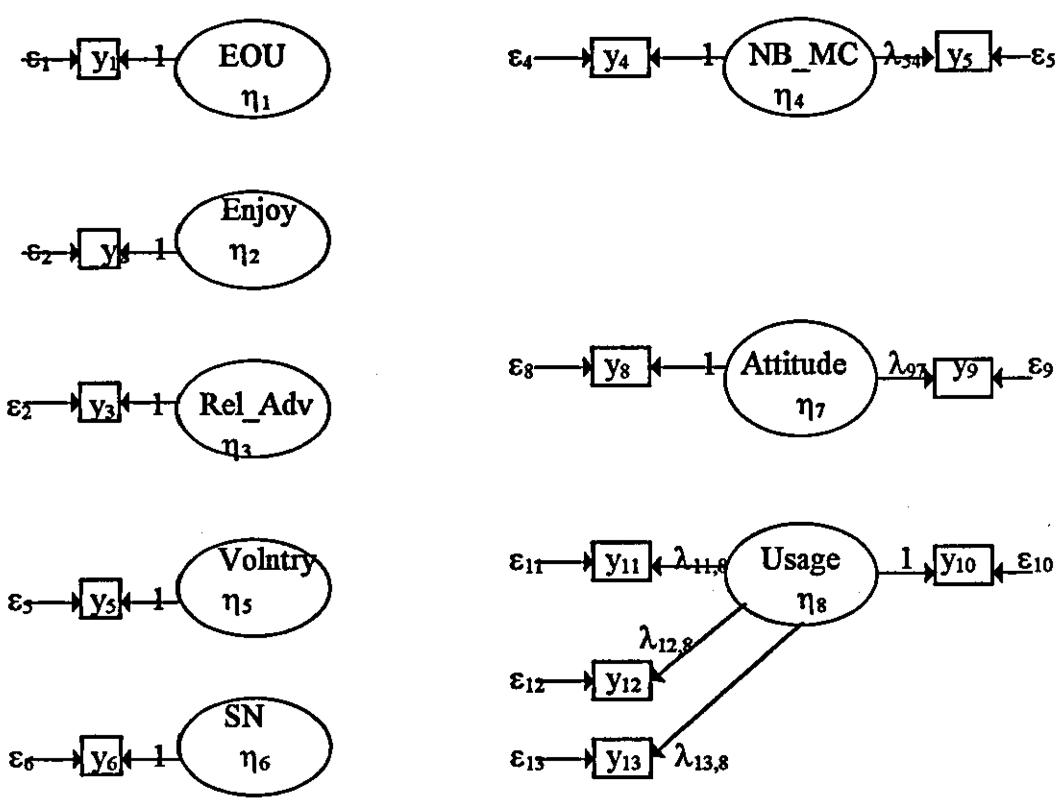

Figure 10.1 :Measurement model for $Y = \Lambda_y \ \eta + \varepsilon$

Table 10.2 Matrix equations defining the measurement model for $Y = \Lambda_y \eta + \varepsilon$

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \\ y_4 \\ y_5 \\ y_6 \\ y_7 \\ y_8 \\ y_9 \\ y_{10} \\ y_{11} \\ y_{12} \\ y_{13} \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & \lambda_{54} & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & \lambda_{97} & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \lambda_{11,8} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \lambda_{12,8} \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & \lambda_{13,8} \end{bmatrix} \begin{bmatrix} \eta_1 \\ \eta_2 \\ \eta_3 \\ \eta_4 \\ \eta_5 \\ \eta_6 \\ \eta_7 \\ \eta_8 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \varepsilon_3 \\ \varepsilon_4 \\ \varepsilon_5 \\ \varepsilon_6 \\ \varepsilon_7 \\ \varepsilon_8 \\ \varepsilon_9 \\ \varepsilon_{10} \\ \varepsilon_{11} \\ \varepsilon_{12} \\ \varepsilon_{13} \end{bmatrix}$$

Table 10.3 Matrix equations defining the measurement model for $X = \Lambda_x \xi + \delta$

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \\ x_5 \\ x_6 \\ x_7 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \\ \xi_5 \\ \xi_6 \\ \xi_7 \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \\ \delta_6 \\ \delta_7 \end{bmatrix}$$

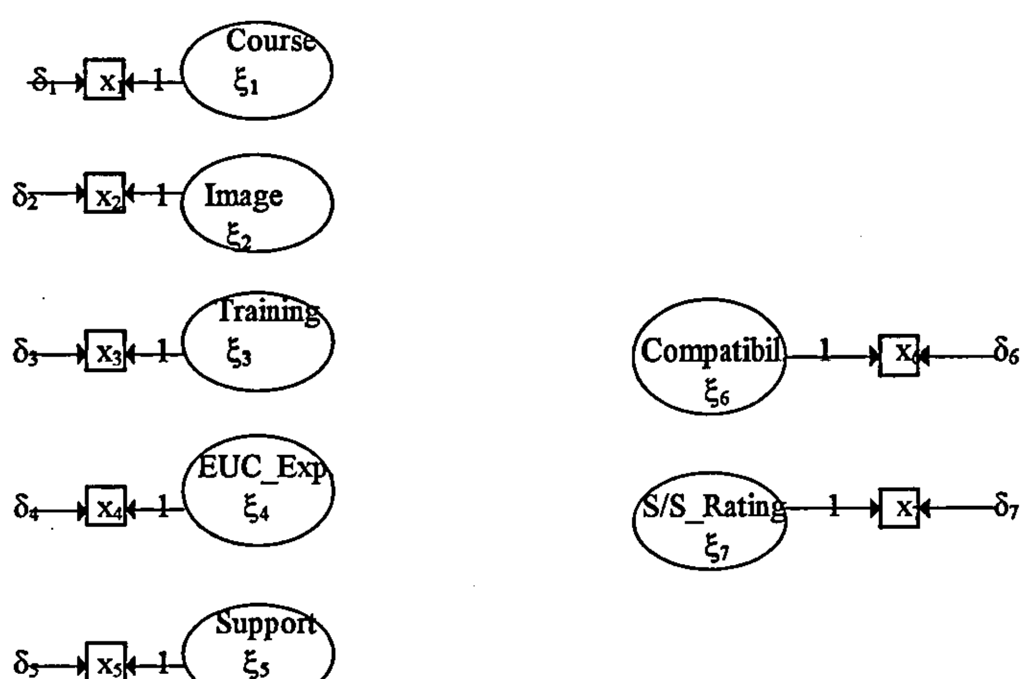

Figure 10.2 :Measurement model for $X = \Lambda_x \xi + \delta$

The Structural Equation Model

The structural equation model refers to relations among exogenous and endogenous constructs or latent variables. The general form of the structural equation model is:

$$\eta = B\eta + \Gamma\xi + \zeta$$

Where - η is an m x 1 vector of latent endogenous variables

- ξ is an n x 1 vector of latent exogenous variables
- B is an m x m matrix of coefficients of the effects of endogenous variables (η's) on endogenous variables (η's).
- Γ is an m x n matrix of coefficients of the effects of exogenous variables (ξ's) on endogenous variables (η's).
- ζ is an m x 1 vector of residuals in the equations

The assumptions in LISREL analysis are:

1. δ is uncorrelated with ξ
2. ε is uncorrelated with η
3. ζ is uncorrelated with ξ
4. δ, ε and ζ are mutually uncorrelated
5. B has zeroes in the diagonal and I-B is non-singular.

Two additional assumptions for employing the maximum likelihood technique for estimating the model are: (1) the data are derived from a random sample of independent observations from a population, and (2) the observed variables have a multivariate normal distribution (Joreskog and Sorbom, 1986). As outlined in the description of data collection procedures (Chapter 4), the data for this study were obtained from randomly selected sample of end users. Multivariate normality is assumed. The matrix of equations defining the initial structural model for Usage is shown in Table 10.4. Figure 10.3 depicts the relationships hypothesized in the initial structural model for Usage and the hypothesized relationships are the same as those in the path diagram (Figure 9.3) in Chapter 9.

Table 10.4 Matrix Equations defining the initial structural model for Usage

$$\eta = B\eta + \Gamma\xi + \zeta$$

$$
\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\\ \eta_5\\ \eta_6\\ \eta_7\\ \eta_8\end{bmatrix}
=
\begin{bmatrix}
0 & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
\beta_{21} & 0 & 0 & 0 & 0 & 0 & 0 & 0\\
0 & \beta_{32} & 0 & 0 & 0 & 0 & 0 & 0\\
0 & \beta_{42} & \beta_{43} & 0 & 0 & 0 & 0 & 0\\
0 & 0 & \beta_{53} & \beta_{54} & 0 & 0 & 0 & 0\\
0 & 0 & 0 & \beta_{64} & \beta_{65} & 0 & 0 & 0\\
\beta_{71} & \beta_{72} & \beta_{73} & 0 & 0 & 0 & 0 & 0\\
\beta_{81} & 0 & \beta_{83} & 0 & \beta_{85} & \beta_{86} & \beta_{87} & 0
\end{bmatrix}
\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\\ \eta_5\\ \eta_6\\ \eta_7\\ \eta_8\end{bmatrix}
+
\begin{bmatrix}
\gamma_{11} & 0 & 0 & 0 & 0 & \gamma_{16} & \gamma_{17}\\
0 & \gamma_{22} & 0 & 0 & 0 & \gamma_{26} & 0\\
\gamma_{31} & 0 & 0 & 0 & \gamma_{35} & \gamma_{36} & 0\\
\gamma_{41} & \gamma_{42} & 0 & 0 & \gamma_{45} & 0 & 0\\
\gamma_{51} & 0 & \gamma_{53} & 0 & 0 & 0 & 0\\
\gamma_{61} & \gamma_{62} & 0 & 0 & 0 & 0 & 0\\
0 & 0 & 0 & \gamma_{74} & 0 & 0 & 0\\
0 & 0 & \gamma_{83} & 0 & 0 & \gamma_{86} & \gamma_{87}
\end{bmatrix}
\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\\ \xi_6\\ \xi_7\end{bmatrix}
+
\begin{bmatrix}\zeta_1\\ \zeta_2\\ \zeta_3\\ \zeta_4\\ \zeta_5\\ \zeta_6\\ \zeta_7\\ \zeta_8\end{bmatrix}
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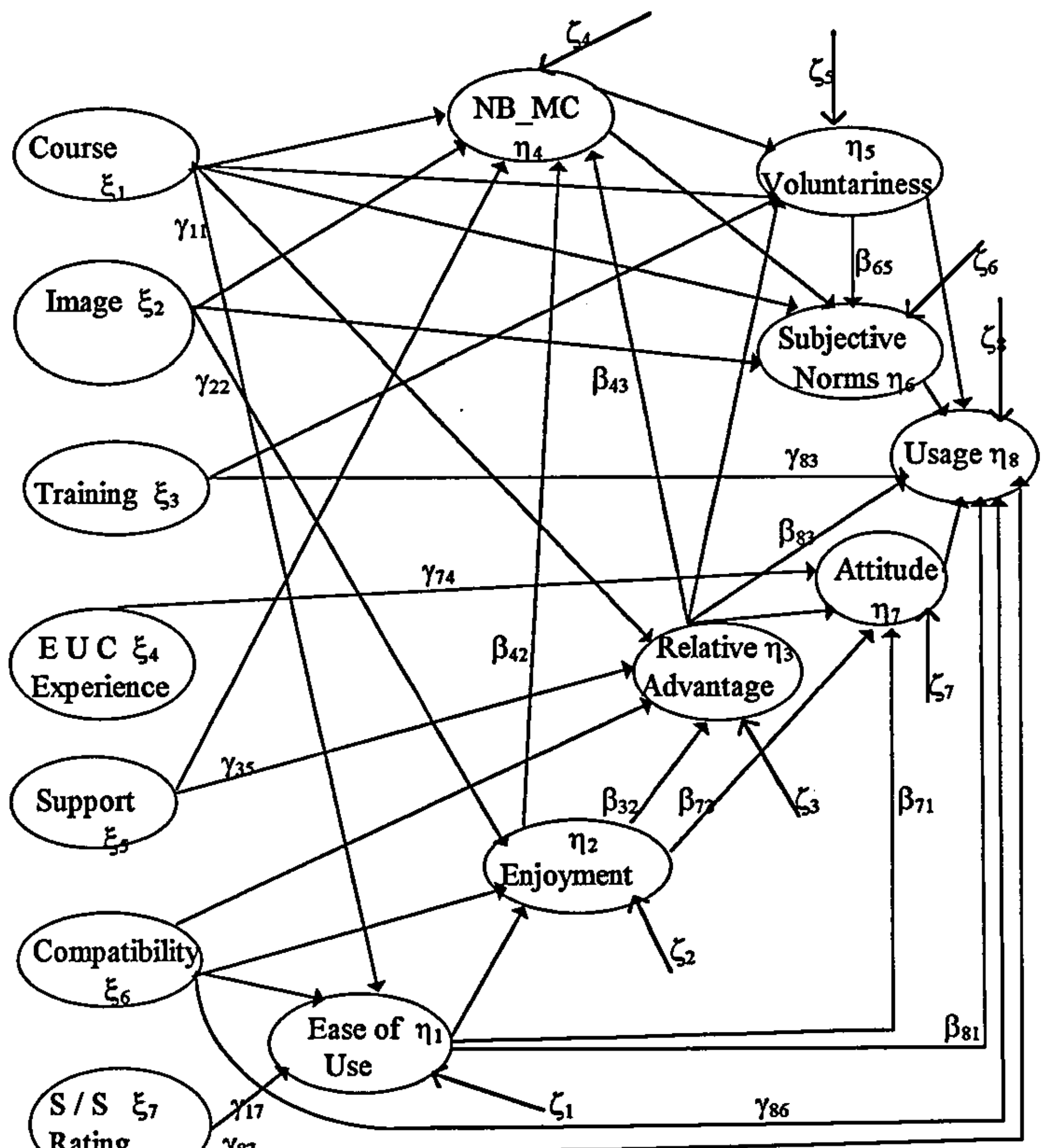

Figure 10.3: The initial structural model for Usage

Evaluation of Structural Model

The structural model depicted in Figure 10.3 and Table 10.4 was tested using the LISREL 7 structural equations computer programme. The PC version of LISREL which is provided as an add-on to the SPSS advanced statistical package was the only code available to the researcher.

From a covariance matrix used as input to the programme prepared using SPSS procedure PRELIS, the variance-covariance matrices were analysed and the measurement and structural parameters were estimated for the specified model. Table 10.5 gives the maximum likelihood estimates (MLE) standardised values of the path coefficients and the corresponding t-values.

Table 10.5 MLE of Parameters — Usage Initial Structural Model

Parameter	Path	Standardised Value	t-value
β_{21}	EOU→ENJOYMENT	0.298	5.239**
β_{41}	EOU→NBMC	-0.038	-.527
β_{71}	EOU→ATTITUDE	0.267	3.299**
β_{81}	EOU→USAGE	0.116	1.763
β_{32}	ENJ→REL_ADV	0.225	3.311**
β_{42}	ENJ→NBMC	0.222	2.767**
β_{52}	ENJ→VOLUNTRY	0.119	2.852**
β_{72}	ENJ→ATTITUDE	0.319	3.776**
β_{43}	REL_ADV→NBMC	0.107	1.564
β_{53}	REL_ADV→VOLUNTRY	-.036	-.558
β_{73}	REL_ADV→ATTITUDE	0.191	2.537*
β_{83}	REL_ADV→USAGE	0.037	0.625
β_{54}	NBMC→VOLUNTRY	-.305	-3.276**
β_{64}	NBMC→SUBJNORM	0.774	5.748**
β_{65}	VOLUNTRY→SUBJNORM	-.021	-.320
β_{85}	VOLUNTRY→USAGE	-.168	-3.287**
β_{86}	SUBJNORM→USAGE	0.175	3.320**
β_{87}	ATTITUDE→USAGE	0.331	3.627**
γ_{11}	COURSE→EOU	-.131	-2.383*
γ_{31}	COURSE→REL_ADV	-.056	-0.967
γ_{41}	COURSE→NBMC	-.236	-3.077**
γ_{51}	COURSE→VOLUNTRY	0.240	3.718**
γ_{61}	COURSE→SUBJNORM	0.177	2.509*
γ_{22}	IMAGE→ENJOYMENT	0.111	2.112*

Table 10.5 MLE of Parameters — Usage Initial Structural Model (Continued)

Parameter	Path	Standardised Value	t-value
γ_{42}	IMAGE→NBMC	0.354	4.633**
γ_{62}	IMAGE→SUBJNORM	0.073	0.944
γ_{53}	TRAINING→VOLUNTRY	0.022	0.355
γ_{83}	TRAINING→USAGE	0.132	2.610**
γ_{74}	EUC_EXP→ATTITUDE	0.159	2.350*
γ_{35}	SUPPORT→REL_ADV	0.128	2.199*
γ_{45}	SUPPORT→NBMC	0.166	2.518*
γ_{16}	COMPATBL→EOU	0.340	5.896**
γ_{26}	COMPATBL→ENJOYMENT	0.373	6.422**
γ_{36}	COMPATBL→REL_ADV	0.206	2.985**
γ_{86}	COMPATBL→USAGE	0.170	2.833**
γ_{17}	SS_RATING→EOU	0.231	4.017**
γ_{87}	SS_RATING→USAGE	0.190	3.513**

** $p < .01$ * $p < .05$

Squared Multiple Correlations for Structural Equations:

EASOFUSE	ENJOYMENT	REL_ADV	NBMC
0.230	0.352	0.180	0.352

VOLUNTRY	SUBJNORM	ATTITUDE	USAGE
0.184	0.615	0.385	0.524

TOTAL COEFFICIENT OF DETERMINATION FOR STRUCTURAL EQUATIONS IS 0.682

MEASURE OF GOODNESS OF FIT FOR THE WHOLE MODEL

DEGREES OF FREEDOM	124
CHI-SQUARE	222.06 (p=.000)
GOODNESS OF FIT INDEX (GFI)	0.940
ADJUSTED GOODNESS OF FIT INDEX (AGFI)	0.898
ROOT MEAN SQUARE RESIDUAL (RMR)	0.047

The next step is to assess the "reasonableness" of the model. As suggested by Joreskog and Sorbom (1986), the following quantities should be examined:

1. Parameter estimates which have negative variances, correlations which are larger than 1 in magnitude, covariance or correlation matrices which are not positive definite.
2. Extremely large standard errors.

3. Squared multiple correlations or coefficients of determination which are negative.
4. Parameter estimates which are correlated very highly.

The output of LISREL for the Usage initial structural model was scrutinized for the occurrence of any of the above four conditions. None of them occured. Thus based on these listed criteria, the model appears to be strong.

The next step is to assess the goodness of fit of the model. One goodness of fit indicator is the chi-square statistic. However, it is recommended not to use the chi-square as a test statistic but as an indication of fit (Joreskog & Sorbom 1986, Hayduk 1987). The fit is assessed in the sense that large values indicate poor fit, and small values indicate good fit. The degrees of freedom serves as the standard by which to judge whether chi-square is large or small. A value of the ratio of a chi-square to the number of degrees of freedom (χ^2/DF) which is less than 5 can be considered adequate for large models (Bollen and Long 1993). Using this test criteria, the value of such a ratio for this model is 1.79 which indicates a very good fit.

Another criterion is the goodness of fit index (GFI) and the adjusted goodness of fit index (AGFI), the closer values are to 1 the better the model fits the data. The values of 0.937 and 0.898 respectively indicate a very good model fit. A third criterion is the root mean square residual (RMR). This is a measure of the average of the residual variances and covariances and values close to zero indicate a good model fit. The value obtained in this model was 0.047 is indicating a very good fit.

For an overall evaluation, the goodness of fit of the model can be said to be extremely good, given the large number of parameters to be estimated.

The next step in the process is to improve the fit of the model by inspecting the structural portion of the model. The path coefficients (βs and γs) were examined to see if they were significantly different from 0. Parameters whose t-values are greater than or equal to ±2 are considered to be significantly different from 0 (Joreskog and Sorbom 1986). For the initial structural model Table 10.5, 28 parameters fell in this group but the remaining nine parameters did not. These nine might really be no difference from zero and so these nine values were all fixed at zero and the revised model was re-estimated. The results are shown in Table 10.6.

Table 10.6 MLE of Parameters — Usage Revised Structural Model

Parameter	Path	Standardised Value	t-value
β_{21}	EOU→ENJOYMENT	0.296	5.192**
β_{41}	EOU→NBMC	0.000	—
β_{71}	EOU→ATTITUDE	0.309	3.899**
β_{81}	EOU→USAGE	0.000	—
β_{32}	ENJ→REL_ADV	0.233	3.440**
β_{42}	ENJ→NBMC	0.229	3.548**
β_{52}	ENJ→VOLUNTRY	0.179	2.838**
β_{72}	ENJ→ATTITUDE	0.325	3.892**
β_{43}	REL_ADV→NBMC	0.000	—
β_{53}	REL_ADV→VOLUNTRY	0.000	—
β_{73}	REL_ADV→ATTITUDE	0.199	2.734**
β_{83}	REL_ADV→USAGE	0.000	—
β_{54}	NBMC→VOLUNTRY	-.306	-3.975**
β_{64}	NBMC→SUBJNORM	0.841	7.980**
β_{65}	VOLUNTRY→SUBJNORM	0.000	—
β_{85}	VOLUNTRY→USAGE	-.173	-3.375**
β_{86}	SUBJNORM→USAGE	0.167	3.167**
β_{87}	ATTITUDE→USAGE	0.430	5.131**
γ_{11}	COURSE→EOU	-.130	-2.368*
γ_{31}	COURSE→REL_ADV	0.000	—
γ_{41}	COURSE→NBMC	-.243	-3.141**
γ_{51}	COURSE→VOLUNTRY	0.236	3.766**
γ_{61}	COURSE→SUBJNORM	0.193	2.770**
γ_{22}	IMAGE→ENJOYMENT	0.111	2.113*
γ_{42}	IMAGE→NBMC	0.394	5.668**
γ_{62}	IMAGE→SUBJNORM	0.000	—
γ_{53}	TRAINING→VOLUNTRY	0.000	—
γ_{83}	TRAINING→USAGE	0.133	2.614**
γ_{74}	EUC_EXP→ATTITUDE	0.160	2.401*
γ_{35}	SUPPORT→REL_ADV	0.141	2.469*
γ_{45}	SUPPORT→NBMC	0.176	2.828**
γ_{16}	COMPATBL→EOU	0.341	5.918**
γ_{26}	COMPATBL→ENJOYMENT	0.373	6.414**
γ_{36}	COMPATBL→REL_ADV	0.198	2.883**

Table 10.6 MLE of Parameters — Usage Revised Structural Model (Continued)

Parameter	Path	Standardised Value	t-value
γ_{86}	COMPATBL→USAGE	0.183	3.070**
γ_{17}	SS_RATING→EOU	0.233	4.048**
γ_{87}	SS_RATING→USAGE	0.209	3.909**

** p < .01   * p < .05

Squared Multiple Correlations for Structural Equations:

EASOFUSE	ENJOYMENT	REL_ADV	NBMC
0.232	0.351	0.180	0.369

VOLUNTRY	SUBJNORM	ATTITUDE	USAGE
0.182	0.653	0.439	0.543

TOTAL COEFFICIENT OF DETERMINATION FOR STRUCTURAL EQUATIONS IS 0.707

MEASURE OF GOODNESS OF FIT FOR THE WHOLE MODEL

DEGREES OF FREEDOM	133
CHI-SQUARE	230.34 (p=.000)
GOODNESS OF FIT INDEX (GFI)	0.937
ADJUSTED GOODNESS OF FIT INDEX (AGFI)	0.901
ROOT MEAN SQUARE RESIDUAL (RMR)	0.048

There was a very small improvement in the model (an increase of chi-square of 8 with an extra 9 degrees of freedom) so that the ratio of the chi-square to the DF of the revised model was 1.73 indicating an improvement of 0.06 in this fit criterion. The root mean square residual was almost unchanged (an increase of 0.001). A comparison of the path coefficients, squared multiple correlations and coefficients of determination for the initial and revised models indicated that the values were only marginally different. The fact that there is such a small improvement is partly explained by the fact that 4 of the 9 paths that were later fixed at 0 had t-values which were not significant at p<0.05 but were significant around p=0.10. The indication is that the four parameters might not have truly been zero. Of course, little improvement was expected as the initial model showed such a good fit.

Finally, one needs to check the modification indices which are measures associated with the fixed and constrained parameters of the model (Joreskog and Sorbom 1989). A modification index (MI) is a measure of predicted decrease in χ^2 if any single constraint is added or removed and the model is re-estimated. It is accompanied by a prediction of the estimated change of that parameter. When the MIs were checked it was noticed that no parameter stood in need of being fixed or relaxed which is a strong support for the overall stability of the model. The overall assessment of the fit criteria indicates that the data fit the hypothesized model for Usage very well.

LISREL Model for EUCS

A separate LISREL model was tested for EUCS. The measurement model for the variables contributing to EUCS is presented in Table 10.7 and Figures 10.4 and 10.5 subsequently.

Table 10.7: EUCS Measurement Model

Construct (Latent)/ Indicator Variable	Observed Variable	Standardised Loading (λ)	r^2
Course (ξ_1)	x_1	0.949	0.900
Image (ξ_2)	x_2	0.949	0.900
Support (ξ_3)	x_5	0.949	0.900
Compatibility (ξ_4)	x_6	0.948	0.899
SS_Rating (ξ_5)	x_7	0.949	0.900
EOU (η_1)	y_1	0.949	0.901
Enjoy (η_2)	y_2	0.949	0.901
Rel_Adv (η_3)	y_3	0.949	0.900
EUCS (η_4)			
Content	y_4	0.504	0.254
Accuracy	y_5	0.540	0.292
Format	y_6	0.617	0.381
Easeofuse	y_7	0.410	0.351

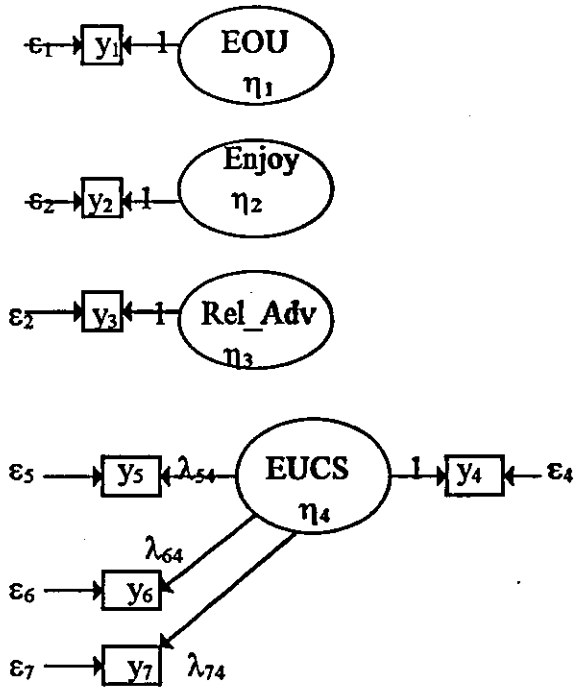

Figure 10.4: EUCS Measurement model for $Y = \Lambda_y \eta + \varepsilon$

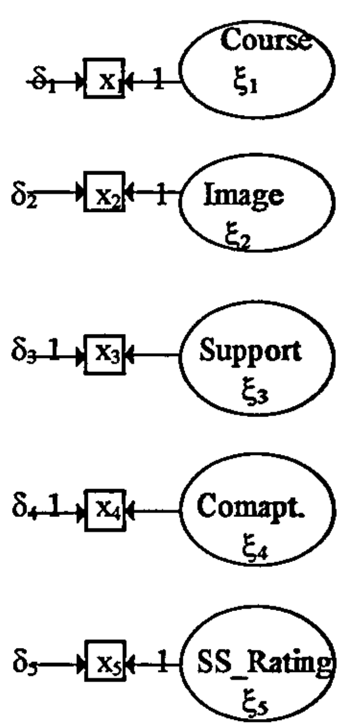

Figure 10.5: EUCS Measurement model for $X = \Lambda_x \xi + \delta$

The EUCS initial structural model is defined in Table 10.8 and depicted in Figure 10.6 below.

Table 10.8 Matrix Equations defining the initial structural model for EUCS

$$\eta = B\eta + \Gamma\xi + \zeta$$

$$\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\end{bmatrix} = \begin{bmatrix}0 & 0 & 0 & 0\\ \beta_{21} & 0 & 0 & 0\\ 0 & \beta_{32} & 0 & 0\\ \beta_{41} & \beta_{42} & \beta_{43} & 0\end{bmatrix}\begin{bmatrix}\eta_1\\ \eta_2\\ \eta_3\\ \eta_4\end{bmatrix} + \begin{bmatrix}\gamma_{11} & 0 & 0 & \gamma_{14} & \gamma_{15}\\ 0 & \gamma_{22} & 0 & \gamma_{24} & 0\\ \gamma_{31} & 0 & \gamma_{33} & \gamma_{34} & 0\\ 0 & 0 & 0 & 0 & \gamma_{45}\end{bmatrix}\begin{bmatrix}\xi_1\\ \xi_2\\ \xi_3\\ \xi_4\\ \xi_5\end{bmatrix} + \begin{bmatrix}\zeta_1\\ \zeta_2\\ \zeta_3\\ \zeta_4\end{bmatrix}$$

Where η_1 is the variable EOU
η_2 is the variable Enjoyment
η_3 is the variable Rel_Adv
η_4 is the variable EUCS

ξ_1 is the variable Course
ξ_2 is the variable Image
ξ_3 is the variable Support
ξ_4 is the variable Compatibility
ξ_5 is the variable SS_Rating

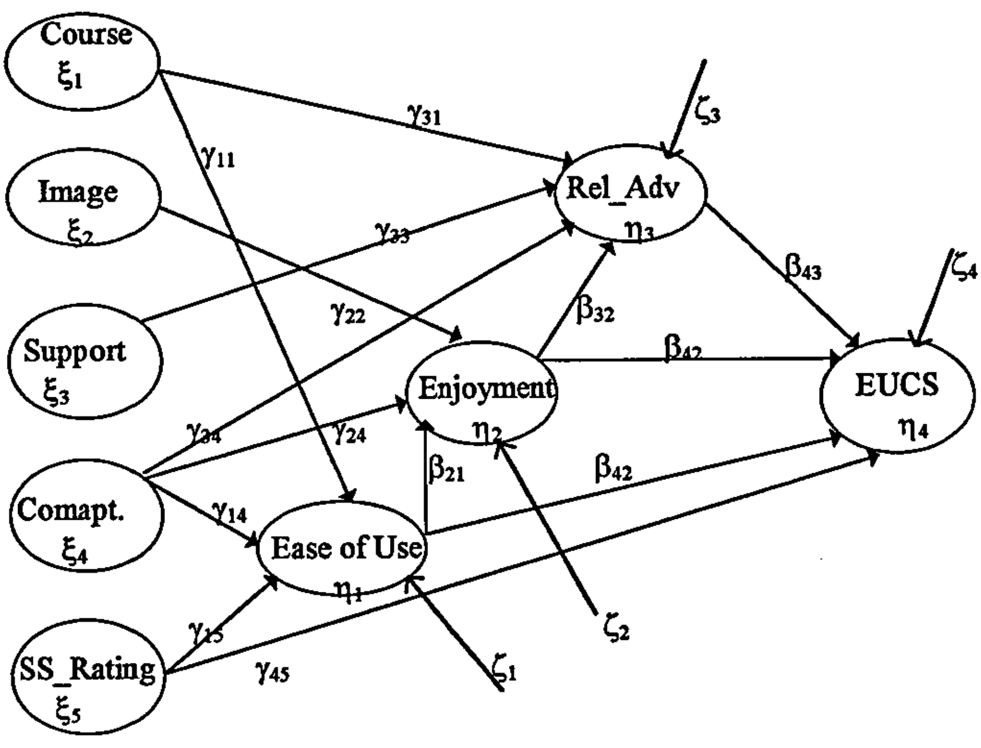

Figure 10.6: EUCS initial structural model

The above EUCS initial model was evaluated following the same steps used to evaluate the Usage model. Table 10.9 shows the resulted parameters estimates of the evaluation.

Table 10.9: MLE of Parameters—EUCS Initial Structural Model

Parameter	Path	Standardised Value	t-value
β_{21}	EOU→ENJOYMENT	0.300	5.261**
β_{32}	ENJOYMENT→REL_ADV	0.227	3.360**
β_{41}	EOU→EUCS	0.280	3.456**
β_{42}	ENJOYMENT→EUCS	0.109	1.334
β_{43}	REL_ADV→EUCS	0.135	1.934
γ_{11}	COURSE→EOU	-.126	-2.295*
γ_{14}	COMPAT→EOU	0.337	5.844**
γ_{15}	SS_RATING→EOU	0.232	4.029**
γ_{22}	IMAGE→ENJYMNT	0.107	2.033*
γ_{24}	COMPAT→ENJYMNT	0.369	6.345**
γ_{31}	COURSE→REL_ADV	-0.051	-0.881
γ_{33}	SUPPORT→REL_ADV	0.128	2.184*
γ_{34}	COMPAT→REL_ADV	0.205	2.980**
γ_{45}	SS_RATING→EUCS	0.407	5.110**

** $p < .01$ * $p < .05$

Squared Multiple Correlations for Structural Equations:

EASOFUSE	ENJOYMENT	REL_ADV	EUCS
0.227	0.348	0.180	0.482

TOTAL COEFFICIENT OF DETERMINATION FOR STRUCTURAL EQUATIONS IS 0.540

MEASURE OF GOODNESS OF FIT FOR THE WHOLE MODEL

DEGREES OF FREEDOM (DF)	37
CHI-SQUARE (χ^2)	87.62 (p=.000)
GOODNESS OF FIT INDEX (GFI)	0.960
ADJUSTED GOODNESS OF FIT INDEX (AGFI)	0.917
ROOT MEAN SQUARE RESIDUAL (RMR)	0.026

Following the assessment criteria used in assessing the Usage model, it was found that the model is reasonable and adequate. The following assessment results were found:

The ratio of χ^2 / DF = 2.37 ,GFI = 0.960 , AGFI = 0.917; RMR = 0.026.

The next step in the process is to improve the fit of the model by inspecting the structural portion of the model. The path coefficients (βs and γs) were examined to see if they significantly differed from 0. Two βs and one γ were found nonsignificant at the $p<0.05$ level; β_{43} was found to be almost significant so it was left and not fixed to zero with the other three parameters and to be further inspected after the model is re-estimated. In fact, when the EUCS initial model was reanalysed β_{43} was found significant.

The modification indices were checked for further parameter analysis and improvement of the χ^2 of the model. The output indicated that $\lambda^{(y)}_{71}$ should to be relaxed to let EUCS and EOU latent variables share a common indicator. The move is theoretically justified since both variables have the same indicator in their scales. The model was finally re-estimated with $\lambda^{(y)}_{71}$ freed and the results are given in Table 10.10 below.

Table 10.10: MLE of Parameters — EUCS Revised Structural Model

Parameter	Path	Standardised Value	t-value
β_{21}	EOU→ENJOYMENT	0.301	5.287**
β_{32}	ENJOYMENT→REL_ADV	0.235	3.483**
β_{41}	EOU→EUCS	0.169	2.207*
β_{42}	ENJOYMENT→EUCS	0.000	—
β_{43}	REL_ADV→EUCS	0.221	3.084**
γ_{11}	COURSE→EOU	-.128	-2.332*
γ_{14}	COMPAT→EOU	0.338	5.859**
γ_{15}	SS_RATING→EOU	0.233	4.047**
γ_{22}	IMAGE→ENJYMNT	0.107	2.038*
γ_{24}	COMPAT→ENJYMNT	0.368	6.326**
γ_{31}	COURSE→REL_ADV	0.000	—
γ_{33}	SUPPORT→REL_ADV	0.138	2.407*
γ_{34}	COMPAT→REL_ADV	0.199	2.899**
γ_{45}	SS_RATING→EUCS	0.440	5.133**

** $p < .01$ * $p < .05$

Squared Multiple Correlations for Structural Equations:

EASOFUSE	ENJOYMENT	REL_ADV	EUCS
0.230	0.349	0.180	0.363

TOTAL COEFFICIENT OF DETERMINATION FOR STRUCTURAL EQUATIONS IS 0.529

MEASURE OF GOODNESS OF FIT FOR THE WHOLE MODEL

DEGREES OF FREEDOM	39
CHI-SQUARE	70.72 (p=.001)
GOODNESS OF FIT INDEX (GFI)	0.968
ADJUSTED GOODNESS OF FIT INDEX (AGFI)	0.935
ROOT MEAN SQUARE RESIDUAL (RMR)	0.026

After the final re-estimation, a final assessment for the EUCS model was carried out. A big improvement in the ratio of χ^2 / DF (1.81 compared to 2.37 for the initial model). The results of this assessment were as the following:

The ratio of χ^2 / DF = 1.81 ,GFI = 0.968 , AGFI = 0.935; RMR = 0.026.

Based on the above criteria, the model appears to be maintaining an excellent fit.

A Combined LISREL Model for Usage and EUCS

A further LISREL model combining both Usage and EUCS was tested to see if there are differences with their models when analysed separately. The results of the combined model revealed that there was no significant differences in the values of βs and γs. A summary results of the combined model is given in the following.

Table 10.11: Summary Results of the Combined Model for Usage and EUCS

Squared Multiple Correlations for Structural Equations:

EASOFUSE	ENJOYMENT	REL_ADV	NBMC	VOLUNTRY
0.234	0.351	0.181	0.369	0.182

SUBJNORM	ATTITUDE	EUCS	USAGE
0.653	0.444	0.362	0.541

TOTAL COEFFICIENT OF DETERMINATION FOR STRUCTURAL EQUATIONS IS 0.763

MEASURE OF GOODNESS OF FIT FOR THE WHOLE MODEL

DEGREES OF FREEDOM	211
CHI-SQUARE	371.13 (p=.000)
GOODNESS OF FIT INDEX (GFI)	0.919
ADJUSTED GOODNESS OF FIT INDEX (AGFI)	0.885
ROOT MEAN SQUARE RESIDUAL (RMR)	0.047

The ratio of χ^2 / DF = 1.76 ,GFI = 0.919 , AGFI = 0.885; RMR = 0.047.

Based on the above criteria, the combined model appears to be very good.

The final LISREL programme (lines of code) used to evaluate the combined model for Usage and EUCS is listed subsequently. Both the structural equation model and the measurement model of the final combined model are depicted in Figure 10.7.

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      USAGE  EUCS/
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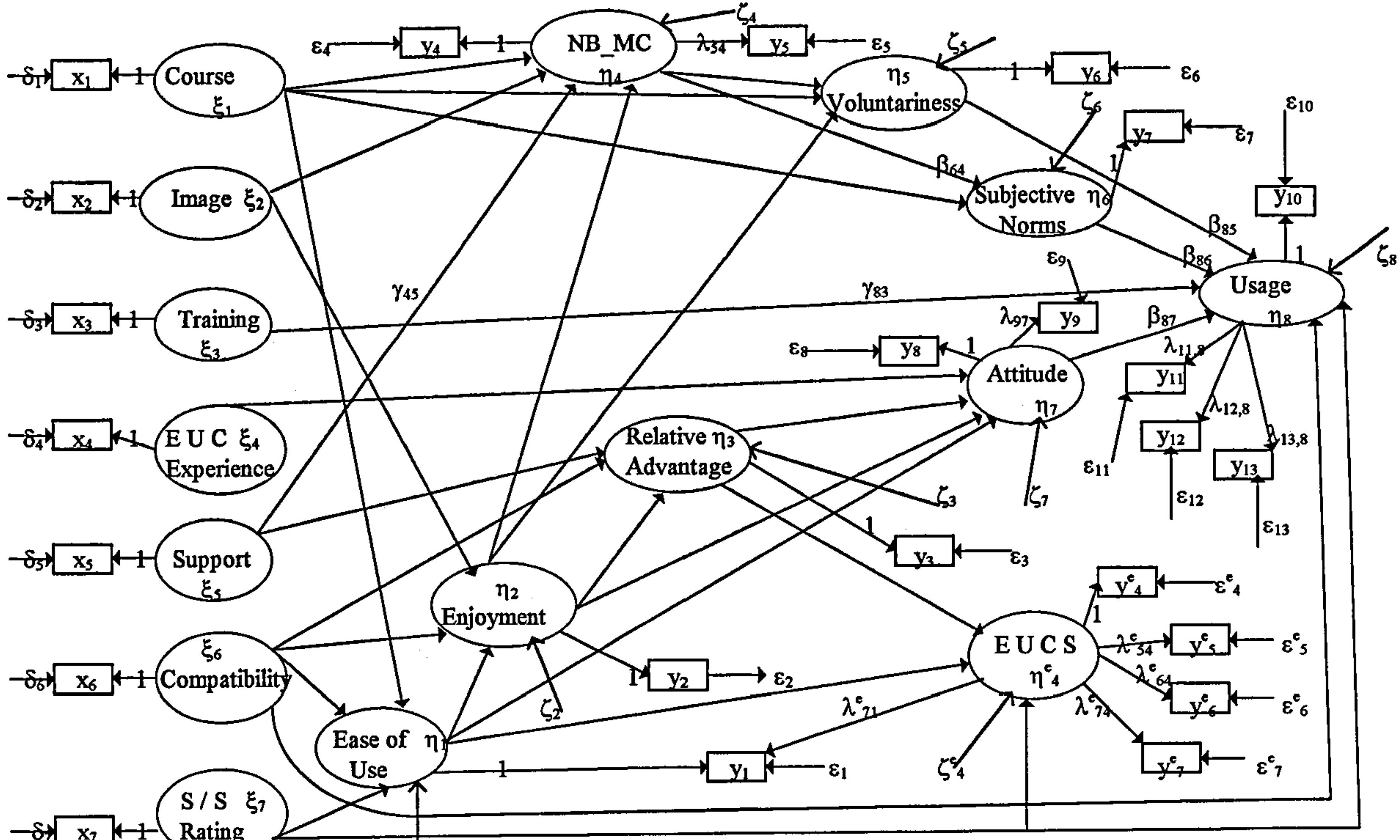

Figure 10.7: LISREL Revised Model for Usage and EUCS

A typical LISREL model output provides the direct, indirect, and total effects of the variables incorporated in the model. Direct effects for Usage and EUCS models are the parameters standardised values in Table 10.6 and Table 10.10 respectively. The indirect and total effects for Usage are given below in Tables 10.12 — 10.15 and those for EUCS are given following that in Tables 10.16 — 10.19. Total effect of a variable on any other variable can be obtained if the direct effect is added to the respective indirect effect of the variable in question.

Table 10.12: Usage model — Indirect Effects of X →Y

X→	Course	Image	Training	EUC_Exp	Support	Compat	SS_Rating
EOU	.000	.000	.000	.000	.000	.000	.000
Enjymnt	-.038	.000	.000	.000	.000	.101	.069
Rel_Adv	-.009	.026	.000	.000	.000	.110	.016
NB_MC	-.009	.025	.000	.000	.000	.109	.016
Voluntry	.070	-.108	.000	.000	-.054	.052	.008
SN	-.212	.353	.000	.000	.148	.091	.013
Attitude	-.054	.041	.000	.000	.028	.321	.098
Usage	-.080	.095	.000	.069	.046	.144	.043

Table 10.13: Usage model — Total Effects of X ⇒ Y

X→	Course	Image	Training	EUC_Exp	Support	Compat	SS_Rating
EOU	-.130	.000	.000	.000	.000	.341	.233
Enjoy	-.038	.111	.000	.000	.000	.474	.069
Rel_Adv	-.009	.026	.000	.000	.141	.308	.016
NB_MC	-.252	.419	.000	.000	.176	.109	.016
Voluntry	.306	-.108	.000	.000	-.054	.052	.008
SN	-.019	.353	.000	.000	.148	.092	.013
Attitude	-.054	.041	.000	.160	.028	.321	.098
Usage	-.080	.095	.133	.069	.046	.327	.252

Table 10.14: Usage model — Indirect Effects of Y → Y

Y → Y	EOU	Enjoy	Rel_Adv	NB_MC	Voluntry	SN	Attitude
EOU	.000	.000	.000	.000	.000	.000	.000
Enjoy	.000	.000	.000	.000	.000	.000	.000
Rel_Adv	.069	.000	.000	.000	.000	.000	.000
NB_MC	.068	.000	.000	.000	.000	.000	.000
Voluntry	.032	-.070	.000	.000	.000	.000	.000
SN	.057	.193	.000	.000	.000	.000	.000
Attitude	.110	.046	.000	.000	.000	.000	.000
Usage	.184	.173	.086	.194	.000	.000	.000

Table 10.15: Usage model — Total Effects of Y ⇒ Y

Y → Y	EOU	Enjoy	Rel_Adv	NB_MC	Voluntry	SN	Attitude
EOU	.000	.000	.000	.000	.000	.000	.000
Enjoy	.296	.000	.000	.000	.000	.000	.000
Rel_Adv	.069	.233	.000	.000	.000	.000	.000
NB_MC	.068	.229	.000	.000	.000	.000	.000
Voluntry	.032	.109	.000	-.306	.000	.000	.000
SN	.057	.193	.000	.841	.000	.000	.000
Attitude	.419	.372	.199	.000	.000	.000	.000
Usage	.184	.173	.086	.194	-.173	.167	.430

Table 10.16: EUCS model — Indirect Effects of X → Y

X →	Course	Image	Support	Compat.	SS_Rating
E O U	.000	.000	.000	.000	.000
Enjoyment	-.039	.000	.000	.102	.070
Rel_Adv	-.009	.025	.000	.110	.016
E U C S	-.024	.006	.031	.126	.043

Table 10.17: EUCS model — Total Effects of X ==> Y

X →	Course	Image	Support	Compat.	SS_Rating
E O U	-.128	.000	.000	.338	.233
Enjoyment	-.039	.107	.000	.470	.070
Rel_Adv	-.009	.025	.138	.309	.016
E U C S	-.024	.006	.031	.126	.483

Table 10.18: EUCS model — Indirect Effects of Y → Y

Y → Y	E O U	Enjoyment	Rel_Adv	E U C S
E O U	.000	.000	.000	.000
Enjoyment	.000	.000	.000	.000
Rel_Adv	.071	.000	.000	.000
E U C S	.016	.052	.000	.000

Table 10.19: EUCS model — Total Effects of Y ==> Y

Y → Y	E O U	Enjoyment	Rel_Adv	E U C S
E O U	.000	.000	.000	.000
Enjoyment	.301	.000	.000	.000
Rel_Adv	.071	.235	.000	.000
E U C S	.185	.052	.221	.000

Usage model was subjected to LISREL analysis and looking at Table 10.13 and Table 10.15 one can see which of the exogenous (external) determinants of Usage had the strongest effect. Thus it is clear that Compatibility achieved the strongest effect (.327), followed by Spreadsheets System Rating (.252), and Training (.133). From among endogenous determinants, Attitude showed the strongest effect (.430) followed by NB_MC (.194) , Ease of Use (.184), Voluntariness and Enjoyment (equally contributed by -.173, 173) respectively, and SN (.167). Rel_Adv was the only weakly contributing (.086) endogenous determinant.

Regarding EUCS, by looking at Table 10.17 and Table 10.19, it can be seen that among exogenous determinants of EUCS, Spreadsheets System Rating achieved the strongest effect (.483), followed by Compatibility (.126). From among endogenous determinants, Rel_Adv was the endogenous variable with the strongest effect (.221) followed by Ease of Use (.185), and finally Enjoyment (.052).

LISREL presented an opportunity to confirm the acceptance of the models which emerged from ordinary regression and path analysis (ORPA) in Chapters 8 and 9. Despite this, a clear discrepancy was found between the solutions obtained through LISREL analysis and ORPA when comparing the effects of determinants of Usage and EUCS. Specifically, discrepancies observed for Rel_Adv, NBMC, Attitude, SN, and S/S Rating as can be seen in Table 10.20 below.

In the Usage model, Rel_Adv and EOU seemed to interchange role in the two methods; Rel_Adv appeared to be stronger in ORPA while it was somewhat weak in LISREL. In contrast, EOU was strong in LISREL while somewhat weak in ORPA. This was thought to be due to the psychometric of the single indicators of both latent variables in the LISREL method. The single measure indicator of EOU looks to be much stronger than that of Rel_Adv.

Although Attitude (A) was strong in ORPA, it appeared to be much stronger in LISREL (.143, .430 respectively). Similarly, SN was somewhat weak in ORPA but appeared to be strong in LISREL (.093, .167 respectively).

Several paths that were significant in ORPA models were found non-significant in the LISREL models (Table 10.6 and Table 10.10). Whereas only one path (Enjoyment→Voluntary) was suggested by LISREL to be significant it was found not to be so in the ORPA model.

For the sake of comparison between the results of ORPA and LISREL. The total effects of all determinants of Usage and EUCS computed by ORPA and LISREL are shown in Table 10.20.

Table 10.20: Total effects found by ORPA and LISREL for two constructs

Determinants	Construct / Method			
	Usage		EUCS	
	ORPA	LISREL	ORPA	LISREL
EOU	0.185	0.184	0.264	0.185
Enjoyment	0.118	0.173	0.145	0.053
Rel_Adv	0.292	0.086	0.142	0.221
NBMC	0.084	0.193	—	—
Voluntariness	- 0.203	- 0.173	—	—
Subjective Norms	0.093	0.167	—	—
Attitude	0.143	0.430	—	—
Course	- 0.110	- 0.080	- 0.072	- 0.024
Image	0.068	0.095	0.037	0.006
Training	0.133	0.133	—	—
EUC Experience	0.020	0.069	—	—
Support	0.044	0.046	0.016	0.031
Compatibility	0.350	0.327	0.214	0.126
S/S Rating	0.222	0.252	0.356	0.483

Strengths of LISREL Modelling

The model formulated for the study, while grounded on well tested theory, is still fairly exploratory. While it can be argued that the use of causal modelling technique (as implemented in LISREL) is somewhat premature, there are many offsetting advantages to employing LISREL.

LISREL allows the testing of both the measurement model and the structural model simultaneously, unlike standard regression and path analysis, where the measures are tested first before the application of the structural equations. The ability to use multiple indicators in the structural model provides "the most complete solution to the estimation problem of structural models" (Kenny 1979), particularly when the research involves testing a causal model in which it is assumed that the latent variables incorporate some error amounts.

Kenny (1979) argues that one commonly accepted approach toward establishing useful causal relations involves the careful study of cross-sectional relationships as is proposed in this research. The technique of causal modelling forces the researcher to specify relationships and assumptions clearly. This was partly applied here as the models that emerged from regression and path analyses were employed to cope with the shortages of computational capacity as stated earlier.

Weaknesses of LISREL Modelling

Most problems in LISREL estimation lie in the chi-square statistic, which measures the overall fit of the model. This statistic is the likelihood ratio test statistic for testing the model against the alternative that the derived covariance matrix is unconstrained, assuming that the model is correct and the sample size is sufficiently large (Hayduk 1987, Bollen 1989). Furthermore, the chi-square is a valid test statistic only if:

- all the observed variables have a multivariate normal distribution;

- the analysis is based on the sample covariance matrix, standardization is not permitted;
- and, the sample is fairly large (Joreskog and Sorbom 1986).

To circumvent the problems with the chi-square statistic, Joreskog and Sorbom (1986) suggest that rather than regarding chi-square as a test statistic, one should regard it as a goodness (or badness) of fit measure in the sense that large chi-square values correspond to bad fit and small chi-square values to good fit. The degrees of freedom serves as a standard by which to judge whether chi-square is large or small (Bollen 1989).

Other weaknesses suggested by Fornell (1983) include:

◊ Problems with model identification which become more acute when methods factors have to be explicitly used.

◊ Problems with chi-square test, the power of which is unknown.

◊ The problem of improper or inadmissible solutions.

Summary

"LISREL is not an easy program to learn how to use, nor is it inexpensive to run....It does, however, provide the most complete solution to the estimation problem of structural models." (Kenny 1979, p162)

In summary, LISREL provides the most suitable analytical technique for this study. The relationships have been hypothesized on the basis of a well established theory (TRA) and model (TAM). Some latent variables were measured using multiple indicators. The LISREL model tests the theoretical part together with the measurement part, which was not possible with first generation statistical tools.

LISREL modelling was taken as the method of choice for testing the models which emerged from ordinary regression and path analysis (ORPA). It was found to be a good tool in verifying 'how far the models fitted the data' whereas ORPA was incapable of delivering such information.

The advantages of using LISREL are summarised by Hughes et al (1986) who state that:

1. the statement of theory is more exact;
2. the testing of theory is more precise;
3. and, the communication of theory is enhanced.

There are certain limitations too, especially the use of composite measures instead of primitive observed indicators of three latent variables. This alternative was considered viable in the resolution of the problem of variables not having typical scales in the MIS literature and in order to cope with the limited PC computational capacity.

The revised model for Usage featured a strong stability in its general structure. Although some paths disappeared and others exhibited some fluctuations in their magnitudes, it can be said that the model is in congruence with TRA and TAM in general.

Chapter 11

DISCUSSION

This chapter discusses the results that emerged from three methods of data analysis employed for this study: correlation and regression analysis, path analysis, and LISREL analysis. Attempts will be made to relate results to hypotheses, to explain some implications of these results, and to explore how they relate to others' findings.

The primary objective of this study was to investigate the factors contributing to spreadsheets usage and end-user computing satisfaction (EUCS). TRA and TAM were used as a base theory and model to generate a model structure for this study. Based on this, a collection of variables from the MIS literature believed to contribute to system usage and EUCS were incorporated into the study model. Ten hypotheses were derived from the model. Data was collected using survey questionnaires administered to students of one year experience in industry throughout the UK. Rigorous analyses for this data were carried out using three methods of analysis: correlation and regression analysis, path analysis, and LISREL analysis.

The method followed in presenting this chapter is that which was recommended by Mitchell and Jolley (1988). They state that if the results are as predicted, the discussion is mainly a "reiteration of the highlights" of hypotheses and findings and if the results are unexpected, "the discussion is usually an attempt to reconcile" them. Thus while following their recommendation, results that were discussed briefly when presented earlier could be reiterated here. Those not discussed earlier will be elaborated in some detail in this chapter.

The following is a presentation, in summary, of the results obtained from the three methods of analysis applied, followed by a comparison of the study findings with previous research and any unexpected findings. Finally, the ten study hypotheses are examined in the light of the results which emerged from these methods of analysis.

Summary of Results Emerging from the Three Methods of Analysis

The main focus variable in this study is spreadsheets usage. Usage was found to be significantly associated with all the proposed contributing factors with the sole exception of gender. Only a negative association was detected with voluntariness indicating that captive usage increases as voluntariness decreases; in other words, usage tends to decrease with a discretionary usage policy. Table 8.1 shows the correlations between the four indicators of usage and the contributing factors whereas Table 8.2 shows pairwise correlation coefficients for all factors.

Multiple regression analysis (MRA), when employed as discussed in Chapter 8, suggested that gender appears to make no contribution to any variable in the proposed model. Thus it was decided to omit this variable from the final model. MRA supported the postulate that most of the hypothesized relationships were confirmed by the data. Thus the results gave very good support to prior studies of factors contributing to user acceptance of information technology. Table 8.14 summarizes the regression analysis results.

MRA succeeded in identifying the factors which contribute to spreadsheets usage and end-user computing satisfaction (EUCS) and the relationships among them. But in order to determine to what extent each factor contributes to the target variables, a more sophisticated method of analysis was needed. Path analysis was chosen to carry out this function.

Tables 9.4 and 9.7 indicate how much each factor contributes to Usage. The most strongly contributing factors listed in order of decreasing contribution were: Compatibility (.350), Relative Advantage (.292), Spreadsheets System Rating (.222), Voluntariness (- .203), Ease of Use (.185), Attitude (.143), SN (.093), and finally Training (.133).

Tables 9.10 and 9.13 indicate how much each factor contributes to EUCS. The most strongly contributing factors listed in order of decreasing contribution were: Spreadsheets System Rating (.356), Ease of Use (.305), Compatibility (.214), Enjoyment (.183), and finally Relative Advantage (.142)

The Usage and EUCS models emerged from ordinary regression and path analysis (ORPA) were subjected to LISREL analysis. Usage factors' contributions analysed by LISREL are given in Tables 10.13 and Table 10.15. Factors are listed here in descending order of contribution: Attitude (.430), Compatibility (.327), Spreadsheets System Rating (.252), NB_MC (.194), Ease of Use (.184), Voluntariness and Enjoyment (equally contributed by -.173, 173) respectively, and SN (.167), Training (.133), Rel_Adv (.086).

EUCS factors' contributions analysed by LISREL are given in Table 10.17 and Table 10.19. Factors are listed here in descending order of contribution: Spreadsheets System Rating (.483), Rel_Adv (.221), Compatibility (.126), Ease of Use (.185), and finally Enjoyment (.052).

LISREL presented an opportunity to confirm the acceptance of the models which emerged from ORPA. The criteria of judging the goodness of fit for these models indicated them to be extremely good models. However, a clear difference was found between the solutions obtained through LISREL analysis and ORPA when comparing the effects of determinants of Usage and EUCS.

Comparing the findings of ORPA to LISREL findings of these determinants clearly reflects the differences between the two methods. The total effects of all determinants of Usage and EUCS are shown in Table 10.20. A large part of the observed differences could be related to the different psychometrics of the measurement models in the two methods. In other words, there were differences in a number of indicators used to measure the latent variables in the two methods.

In summary, these three methods of analysis were successfully applied to analyse such large models. Each method contributed to the analysis with increasing power, as each method fed into the next. Starting with the least powerful correlation analysis, followed by the more powerful regression and path analysis, and finishing with the most powerful and sophisticated technique for structural modelling : LISREL.

Study Findings and Previous Research

The study findings confirm the importance of individual, organisational, and IT characteristics in influencing beliefs about the system and about the work environment. Voluntariness, normative belief and motivation to comply (NBMC), relative advantage, enjoyment, and ease of use were found to mediate relationships between these characteristics and attitudes, subjective norms, and usage. Results show that voluntariness and NBMC mediate relationships between these characteristics and subjective norms. They also show that relative advantage, enjoyment, and ease of use play very important roles in mediating the relationships between these characteristics and attitudes towards using the system and user satisfaction.

Furthermore, relative advantage and enjoyment were found to affect beliefs in the workplace. Attitude towards using was found to mediate the relationships between beliefs about the system and usage. In parallel to this, subjective norms was found to mediate relationships between beliefs in the workplace and system usage.

User training was found to be associated with decreased voluntariness (i.e., more tendency to enforce a compulsory usage policy) and a higher degree of system usage. EUC support was found to be associated with positive norms in the work-place and more favourable beliefs about the advantages of the system. It would appear that increased training programmes and EUC support may foster a feeling of "self-efficacy" (Gist 1987), that is, the belief that one can develop the skills necessary to effectively use EUC systems (e.g., spreadsheets) and strengthen confidence in one's ability to master and use them in one's work (Igbaria 1993).

The direct and indirect effects of training on usage are consistent with the findings of Nelson and Cheney (1987), Igbaria (1990), and Torkzadeh and Dwyer (1994) that showed strong correlations between training and MIS success (here usage or user acceptance of spreadsheets).

This also indicates the important role which user training plays in influencing users' perceptions and beliefs, and eventually the acceptance and use of the system. This suggests that organisations should establish training programmes and users should be trained whenever introduced to new information technology (IT) until they feel comfortable with it. Ronen et al (1989) and Mason and Willcocks (1991) contend that spreadsheet packages have made a major contribution to analysis and problem solving but users need to be concerned with good spreadsheeting practice. This can only be achieved through well-designed training programmes which if not sufficiently provided will hinder its proper adoption (Keane and Mason 1989) and potential error multiplies (Schofield 1987).

There are many reported incidents of threatening risks associated with misuse of spreadsheets (e.g., Creeth 1985; Freeman 1986; Ditlea 1987). Most of which, when carefully studied, were found to be due to lack of proper training. As Davis (1984) suggests, training is perhaps the most effective tool for minimizing the risks associated with end-user computing. Along this direction, Nelson (1991) argues that training end users to handle data, applications, and communication may be considered a form of "preventive maintenance".

EUC support is of critical importance in promoting EUC effectiveness (here end-user system acceptance) (Igbaria 1990). This is supported here by the direct effect of support to relative advantage and NBMC. EUC support is studied here as application development support and general EUC support which includes management support and information centre (IC) support. The support during application development is an apparent need to ensure building of good systems along the lines suggested by Batson (1986) and Williams (1987). This study findings suggest that most support was mostly through self-support then colleagues and the least support was the organisational support. Management support and IC support are considered to be influential in helping end-users to apply computer technology in support of a wider variety of business tasks. Findings also indicate that management and IC support were not sufficient.

A strong indication was found that end-users were highly dependent on themselves and their peers in acquiring knowledge and skills when building spreadsheets applications. This finding supports the findings of Cragg and King (1993) which showed low levels of support during the process of building spreadsheets models. They argue that an end-user can pick up rudiments of spreadsheets from a colleague over lunch time which could lend an explanation to the high percentage of erroneous spreadsheets models. They claimed that at least 25% of investigated models contained errors.

This suggests that training programmes designed to increase individuals' knowledge about the proper spreadsheeting process and their operations and providing sufficient support may be beneficial in cultivating positive norms and reducing potential attitudinal barriers to their use. Ad hoc and conventional training programmes should be carried out to help in alleviating these problems. Some sort of training programmes that might be of great demand could be organised to cover the following topics:

I. spreadsheets basic features

II. spreadsheets model building

III. spreadsheets advanced features.

A potential help in meeting these demands is the readily available computer-based tutorials beside the human instruction. Hicks et al (1991) indicate that no difference was found in students' attitude towards computer-based instruction and human instruction of spreadsheets. However, they found that the ability to comprehend and immediately apply the software to a task is greater with human instruction than with computer-aided instruction.

Leitheiser and Wetherbe (1986) suggest a practical approach for designing support services as well as establishing a mechanism for implementing different service support levels by MIS department to end-users' departments. These services include:

1) general consulting,

2) product support,

3) hotline/help desk,

4) technical support,

5) quality assurance,

prior

6) and end-user training.

This approach is to use an IC to deliver these services. An IC is an organisational unit, usually part of the MIS department, whose principle function is to facilitate and coordinate end-user computing by offering support services.

The importance of prior computer experience in promoting increased user acceptance of IT was highlighted by the finding that EUC experience had a strong direct effect on attitude towards using spreadsheets. Findings of this study showed that EUC experience is associated with increase in system usage. This supports the findings of Baxter and Oatley (1991) who found that spreadsheets are most usable for users who are already familiar with spreadsheets.

Positive EUC experiences in this regard may also help in improving individuals' perceptions about the impact of spreadsheets on their jobs and organisations. It may also increase their awareness as well as strengthen their beliefs about potential difficulties surrounding effective use of these systems.

Taken together with the effect of user training on the work environment norms, these findings emphasize the need for designing mechanisms to improve user perceptions and usage. This suggests that providing end users with some sort of (training programmes, newsletter, etc.) for encouragement and increase of individuals' familiarity with EUC facilities (e.g., spreadsheets) would thereby improve their perceptions and usage eventually (Igbaria 1993). In addition, the provision of opportunities to gain experience with EUC facilities, specifically to new or inexperienced users, would be beneficial in promoting significant increase in usage.

The importance of system characteristics has been widely recognised (Davis 1986, Davis et al 1989, Davis 1993). In this study, spreadsheet system rating (SS_Rating), which measures the system characteristics perceived by the user, was found to affect usage and satisfaction directly and indirectly. The better user perception of the system characteristics the higher the level of satisfaction and usage will be. SS_Rating has an indirect effect through ease of use (consistent with the observation of Davis 1993) which in turn affect enjoyment and attitudes which eventually affect usage.

Compatibility of the system to task performed is an IT characteristic found to be close to system characteristics. Compatibility was found to have direct effect on usage and an indirect effect through ease of use, enjoyment, and relative advantage. This points to the importance of the degree of fit between the task to be performed and the spreadsheets system functions used to perform such a task. The more compatibility between the system and the task the more easy to use, enjoyable, and advantageous the use of the system will be.

Taken together with system rating, these findings emphasize the need to establish a convention among users that "spreadsheets should only be used for what they were intended to be used for". In this respect, Keane and Mason (1989) conclude that "spreadsheets are a first class tool, but to get the best out of them needs discipline. Users and staff need to be aware of the spreadsheets limits and penalties in exceeding them".

Beliefs about spreadsheets (relative advantage, enjoyment, and ease of use) have strong direct effects on attitude towards using and satisfaction. Over and above that, each of relative advantage and ease of use has a direct effect on usage. This shows the important roles that these two factors play in influencing user's attitudes and eventually the acceptance and use of the system. In addition, relative advantage and ease of use are found to be by far the most important determinants of attitudes and usage (Davis 1986, Davis et al 1989, Eason 1992, Igbaria 1993, and Davis 1993). For example, Eason (1992) argue that ease of use, functionality, usability and acceptability are related system and application characteristics which are particularly important to discretionary users.

The study findings support these earlier findings with the enjoyment factor being incorporated for a more integrated picture of the user acceptance model of IT. In accord with the findings of Davis et al (1992), besides the direct effect of ease of use (EOU) and enjoyment on attitudes, EOU was found to affect attitude indirectly through enjoyment which in turn affects relative advantage. This implies that the system is perceived to be easier by users when they find it enjoyable and use will be more enjoyable when perceived more advantageous in their work. Viewed another way, enjoyment has greater effect on attitudes for systems that are perceived relatively advantageous than those that aren't and ease of use has greater effect on attitude for systems that are perceived enjoyable to use than those that aren't.

Davis et al (1992) argued that this pattern of results should mitigate concerns that making computer systems more enjoyable to use would encourage inappropriate or wasteful usage habits. They added that to the contrary, as in our findings, increasing the enjoyability of a system would enhance the acceptability of useful systems but have less of an effect on the acceptance of useless systems. The findings of this study support these views as enjoyment was highly correlated with all four measures of usage (daily use 0.30 , usage frequency 0.41, sophistication 0.22, and usage level 0.30; all at $p<.01$).

However, the high correlation between enjoyment and attitude (0.41) and between enjoyment and usage frequency (0.41) might raise some reservation and cast suspicion of wasteful usage habits. In reference to what was said earlier, enjoyment might thus be considered a secondary requirement in contrast with the primary requirements for designing well perceived advantageous and easy to use systems. Thus enjoyment in systems shouldn't be ruled out or even overlooked as it is believed that the gain of its positive effects by far exceeds its negatives (if any) and the enforcement of some usage policy measures in this regard should take care of these negatives if they really exist.

Adams et al (1992) call the notion of the amount of usage due to lack of alternatives or compulsory policy as "captive use". They claim that such circumstances could lead to an understatement of the true relationships between contributing factors and usage. From this perspective, voluntariness and normative beliefs and motivation to comply (NBMC) were inspected for the first time in this study as beliefs in the workplace. Voluntariness was found to have strong direct negative effect on usage and another strong indirect negative effect through subjective norms (SN). This suggests that, taking voluntariness alone, an increase in usage is subject to less voluntariness; in other words, in a workplace where voluntary usage policy is applied a decrease in usage might be expected. This is consistent with Adams et al's observation.

The role of top management and peers in the workplace was considered to be important in past studies examining information system success (e.g., Melone 1990 and Thompson et al 1991). NBMC, which comprises beliefs of peers and superiors about using the system, was examined to look for evidence supporting the significance of any of these effects. NBMC was found to have a strong positive indirect effect on usage through SN by influential peers and through voluntariness by top management enforcing compulsory usage policies.

In general, the findings from this study strongly support the importance of all of these factors. The study findings fully support the theory of reasoned actions (TRA) put forward by Fishbein and Ajzen (1975) and Ajzen and Fishbein (1980). Of particular importance was the support for the relationship between subjective norms (SN) and Usage (behaviour). No previous research in the field provided empirical support regarding this relationship.

TRA does succeed in integrating a user's evaluative response with his or her behaviour. Since the acceptance of an information system has some relationship to its use (or lack of use), this would be seen to offer advantages for IS research. Brancheau and Wetherbe (1990) contend that understanding the social forces underlying technology diffusion is critical for effective management of the process.

The basic structure of the base theory model (TRA) used here, specifically the social-norm (NBMC) construct, permits integration of factors (e.g., top management, peers) considered to be important in past studies examining information system success.

TAM was also supported, with a minor variation, when Enjoyment was incorporated in the study model. In TAM (Davis et al 1989 and Davis 1993), EOU was found to affect attitude (A) directly and indirectly through usefulness (Rel_Adv). This study supports the direct link EOU → A but the indirect one was found to be working through Enjoyment (which was not part of TAM) rather than through Rel_Adv. The EOU → Enjoyment → Rel_Adv route confirms a previous finding by Davis et al (1992).

The usage — EUCS relationship was found to be of an ambiguous entity and equivocal. Although EUCS was strongly correlated with the four indicators used to measure usage, " correlation does not imply causality" (Kenny 1979, p 1). Kenny elaborated that three commonly accepted conditions must hold to be able to claim that X causes Y:

1. time precedence;
2. relationship;
3. and nonspuriousness.

Torkzadeh and Dwyer (1994) report that this issue is still debated among MIS researchers and practitioners. It would require a separate dedicated research study to investigate the causality direction between the two constructs.

In fact the study succeeded in supporting the fundamental similarity between satisfaction and the social and cognitive psychologists' notion of an attitude suggested by Melone (1990) and Doll and Torkzadeh (1991). Melone (1990) raised the issue that the concept of "user satisfaction" posed some problems when used to evaluate a computer system. It is not clearly defined, nor is there a theoretical base for its development. She suggests that "user attitude" might be a better substitute, as it already has a strong theoretical foundation in many other disciplines. This study investigated both concepts and found that user attitude is an antecedent to and a major determinant of system usage whereas user satisfaction is not. The direction suggested by this study is to consider both concepts as complements to each other rather than of one to substitute for the other.

Quite clearly, the estimation task is quite complex. The measurement model requires a factor analysis type model and the structural model is typically a multiple regression type model. Reliability and factor analyses were conducted for the measurement model (Chapter 7). The structural model was subjected to multiple regression and path analyses to estimate the direct, indirect, and total effects for factors incorporated in this model.

The LISREL analytical technique is qualified to achieve the estimation in a one-step process instead of the above two-step process. The application of LISREL here played the role of a confirmatory technique for the study model as a whole. A separate model for each of Usage and EUCS and a combined model of the two were tested using LISREL modelling. LISREL suggest that the three revised models were of extremely good fit to the data.

Unexpected Findings

The factor analysis in Chapter 7 managed to show that Compatibility and relative advantage are two separate constructs. However, Compatibility was previously suggested to be an endogenous construct as it appeared confounded with relative advantage in the research of Moore and Benbasat (1991).

Multiple regression analysis (MRA) suggested that Image and Compatibility were to be considered exogenous variables rather than endogenous, as it was first thought to be. This finding pointed to the fact that both of them are considered to be determined outside the study model (from the definition of exogenous variable). This finding was not expected and no research was found to confirm this in the literature. This study has no explanation to this finding other than that this might be an IT specific feature and hence peculiar to spreadsheets and not to computer worksations which was investigated by Moore and Benbasat (1991).

Gender was first incorporated as a demographic variable in the study's proposed model. MRA discovered its non contribution to both the Usage and EUCS models. Although this was not expected, it is consistent with the finding of Igbaria et al (1989) who found no relationship between gender and usage.

Some beliefs about spreadsheets were found to affect beliefs about the work environment. The following set of relationships were thought to be non-significant but unexpectedly found significant:

1) Rel_Adv → NBMC

2) Rel_Adv → Voluntariness

3) Enjoyment → NBMC

4) Enjoyment → Voluntariness.

Beside their hypothesized indirect effect on Usage, several factors were unexpectedly found to affect Usage directly. Thus Voluntariness, Training, Compatibility, and EOU were found to have significant direct effects on Usage.

This hints to some sort of variation between this model and TRA and shows their important direct contributions over that channeled through intervening factors. When LISREL was fed with the models emerged from ORPA, it was found that some direct paths not in line with TRA general structure were suppressed. Some of these paths, for example, are:

Rel_Adv → Usage (supported by TAM)

EOU → Usage

Enjoyment → EUCS

This points to the fact that LISREL tends to channel these direct effects to go through mediating variables which gives an output model of more matching to the base model of TRA.

Another credit for LISREL is being able to test a structural model as a whole in one step. The conventional multiple regression analysis is only able to regress only one endogenous variable at a time whereas LISREL is capable of regressing all endogenous variables simultaneously.

Hypotheses Testing

This section interprets the results of the structural (causal) model to provide evidence for support or lack of support for each of the hypotheses presented in Chapter 3. These hypotheses were tested by examining the βs in the ordinary regression and path analysis (ORPA) model, the βs and γs in LISREL structural model, and their statistical significance. Each hypothesis is restated below and evidence for support or otherwise is then presented. The models depicting significant paths that emerged from ORPA and LISREL are shown in Figures 9.2 and 10.7 respectively.

H1: Attitude towards using S/S will mediate the relationships between beliefs about S/S and S/S usage.

There is a very strong support for this hypothesis in ORPA ($\beta = 0.143$, $p<.01$) and in LISREL ($\beta = 0.430$, $p<.001$). The resulting implication is that attitude towards using spreadsheets play a strong role in determining spreadsheets usage. Attitude towards usage is based on the beliefs about spreadsheets and this is related to the end users performance in their jobs as will be discussed later.

H2: Subjective norms will mediate the relationships between beliefs about the work environment and S/S usage.

This hypothesis is supported in ORPA ($\beta = 0.093$, $p<.05$) and in LISREL ($\beta = 0.167$, $p<.01$), although the relationship is not as strong as that for attitude. As proposed by Fishbein and Ajzen (1975), both attitude and norms are important determinants of behaviour which , in this study, is spreadsheets usage.

H3: Each of compatibility, relative advantage, ease of use, and enjoyment will have a significant effect on attitude towards using S/S.

All four relationships with attitude towards usage, with the sole exception of compatibility, are strongly supported in ORPA ($\beta = 0.317$, $p<.001$; $\beta = 0.174$, $p<.001$; $\beta = 0.200$, $p<.001$) and in LISREL ($\beta = 0.199$, $p<.01$; $\beta = 0.309$, $p<.001$; $\beta = 0.325$, $p<.001$) respectively. Compatibility affects attitude indirectly through these three mediator variables as it is found to be an exogenous determinant.

H4: Each of normative beliefs and motivation to comply (NBMC), voluntariness, and image will have a significant effect on subjective norms (SN).

All three relationships with subjective norms are strongly supported in ORPA ($\beta = 0.427$, $p<.001$; $\beta = -0.135$, $p<.01$; $\beta = 0.253$, $p<.001$) respectively. In LISREL, both voluntariness → SN and image → SN were found non-significant in contrast with that of NBMC→ SN ($\beta = 0.841$, $p<.001$) which appeared to be the strongest relationship in the whole model.

H5: End-user background variables will have significant effects on compatibility, relative advantage (Rel_Adv), and ease of use (EOU).

End-user background variables are: end-user training, EUC experience, and EUC support. As compatibility was transferred from an endogenous to an exogenous variable (Chapter 8) and none of the end-user background variables has a significant effect on either EOU or Rel_Adv, this hypothesis is not supported.

H6: Spreadsheets System Rating (SS_Rating) will have significant effects on relative advantage, ease of use, and enjoyment.

SS_Rating only has a significant effect on ease of use ($\beta = 0.267$, $p<.001$) in ORPA and ($\beta = 0.233$, $p<.001$) in LISREL respectively. The two relationships SS_Rating → Rel_Adv and SS_Rating → enjoyment were found non-significant. Thus this hypothesis is only partially supported.

H7: Demographic variables will have significant effects on beliefs about the work environment.

Demographic variables were reduced to just one variable: course, as gender appeared to have no significant effect on any variable in the study model and was, as a result, totally excluded. Beliefs about the work environment incorporate three variables: NBMC, voluntariness, and image. Image was transferred from an endogenous to an exogenous variable (Chapter 8). This hypothesis can be rephrased accordingly: Course will have significant effects on both NBMC and Voluntariness. The ORPA and LISREL analysis results show that both paths (Course → NBMC and Course → Voluntariness) were significant (β = - 0.136, $p<.01$; β = 0.199, $p<.001$) in ORPA and (β = -0.243, $p<.001$; β = 0.236, $p<.001$) in LISREL. Thus it is fair to conclude that this hypothesis is supported.

H8: Demographic variables will have significant effects on relative advantage, and ease of use.

According to the newly derived hypothesis (H7) above, this hypothesis is testing the significance of the two paths: Course → Rel_Adv and Course → EOU. The ORPA results show that both paths were significant in ORPA (β = - 0.115, $p<.05$; β = - 0.182, $p<.001$). In LISREL the path Course → Rel_Adv was not significant whereas Course → EOU was significant (β = -0.130, $p<.05$). Thus this hypothesis is partially supported.

H9: Each of compatibility, relative advantage, ease of use, and enjoyment will have a significant effect on EUC Satisfaction (EUCS).

Compatibility changed status as mentioned earlier when discussing H3 above. In ORPA the other three paths were all significant (β = 0.142, $p<.01$; β = 0.264, $p<.001$; β = 0.145, $p<.01$) respectively. In LISREL enjoyment → EUCS was found non-significant and enjoyment affects EUCS indirectly through Rel_Adv, but Rel_Adv → EUCS and EOU → EUCS were both significant (β = 0.221,

$p<.001$; $\beta = 0.169$, $p<.05$ respectively). Thus, this hypothesis is also partially supported.

H10: EUCS will mediate the relationship between beliefs about S/S and S/S usage.

End-user computing satisfaction (EUCS) was expected to impact spreadsheets usage and be influenced by beliefs about spreadsheets (compatibility, Rel_Adv, EOU, and enjoyment). H9 demonstrates the second part of this expectation. Regarding as to whether EUCS mediates the relationship between these beliefs and usage, neither ORPA nor LISREL revealed significance of this relationship. Thus this hypothesis is not supported.

However, the relationship between satisfaction and usage was found to be equivocal and is still being debated by MIS researchers (Torkzadeh and Dwyer 1994). Baroudi et al (1986) suggest three models for the relationship between satisfaction and usage:

I. the dominant or "traditional model": satisfaction and usage are not related;

II. usage → satisfaction: as system usage increases it leads to increased user satisfaction. This model is based on the belief that system use leads users to be more familiar with the system and to discover new uses for it which will, in turn, lead to enhanced user satisfaction with the system;

III. satisfaction → usage: the more satisfied the user is with the system the more he or she will be inclined to use it. This model assumes that as use demonstrates that a system meets a user's needs, satisfaction with the system should increase, which should further lead to greater use of that system.

Furthermore, Delone and McLean (1992) argue that system use and user satisfaction affect each other at the same time and that the type of relationship between them is "reciprocal" (satisfaction ↔ usage). This study hypothesized the third model of Baroudi et al (1986) and found no support for this type of relationship.

In summary, the empirical evidence is mixed regarding the type of relationship between satisfaction and usage. However, a further analysis was carried out to investigate if any of the other models should emerge, including the reciprocal relationship, but it was found that the traditional model was the only one supported by this study. Thus, this hypothesis is not supported.

CHAPTER 12

SUMMARY, CONCLUSIONS AND IMPLICATIONS

This study set out to explore the factors contributing to spreadsheets usage and end-user computing satisfaction. The theory of reasoned action (TRA) and the technology acceptance model (TAM) suggested a model for assimilating several factors from the information systems literature hypothesized to contribute to usage and satisfaction.

A self-administered survey questionnaire provided data from 333 end users from university final year students who have been in industry throughout the UK for one year. Of these end users, 197 were studying on business programmes and 133 studying on engineering programmes, and only 23 were from chemistry.

Major Findings of the Study

The initial statistical analysis using correlations and regressions gave no support to the hypothesis that gender is among those factors anticipated to contribute to spreadsheets acceptance. This suggested that gender is not likely to help in the explanation of the reported differences in spreadsheets acceptance. Similarly, no support was found for the hypothesis that image and compatibility can be predicted from the study model variables. Image is probably an organisational characteristic while compatibility is probably task and individual as well as IT characteristic. Hence, it makes sense to take each of them as a predetermined variable outside the model (i.e., an external or exogenous variable).

This study strongly indicated that the most immediate determinants of spreadsheets usage were user training, spreadsheets system rating, compatibility, voluntariness, relative advantage, ease of use, subjective norms, and attitudes toward use. Subjective norms and attitudes toward using spreadsheets had only direct effects on spreadsheets usage, in contrast to other determinants which also had indirect as well as direct effects on usage through mediating variables.

In fact, the impact of beliefs in the workplace (voluntariness and normative beliefs and motivation to comply [NBMC]) and beliefs about spreadsheets (relative advantage, enjoyment, and ease of use) on usage operate through subjective norms and attitudes toward using spreadsheets respectively. Furthermore, the results also demonstrated that user training, compatibility, spreadsheets rating, voluntariness, relative advantage, and ease of use all had both strong direct and indirect effects on usage.

An important contribution from this research is the support it lends to the relationship between subjective norms and spreadsheets usage. No previous research has discussed this relationship explicitly. Understanding of this relationship has important implications for the introduction of new information technology into modern organisations.

Regarding user satisfaction, this study supports the direction suggested by Melone (1990). She suggested that user attitude might be a better substitute, as it already has a strong theoretical foundation in many other disciplines. This study points to attitude being an antecedent to and a predictor of usage whereas satisfaction does not prove to be so. Hence, this study suggests that attitude is "more than" a substitute for satisfaction and that satisfaction should be used as a complement to usage when evaluating end-users' acceptance of computer systems. Being employed together, both subjective and objective measures should compensate for the shortcomings of each other and lend more insight in the situations of captive use and the less accurate self-report measures applied these days in the MIS research.

This study also showed that EUC experience, compatibility, relative advantage, enjoyment, and ease of use are major determinants of users' attitudes toward using spreadsheets. The last four determinants of attitude plus spreadsheets rating are the five major determinants of satisfaction with spreadsheets. NBMC, image, and voluntariness were found to be major determinants of subjective norms. Relative advantage and enjoyment were found to affect beliefs in the workplace (voluntariness and NBMC).

The type of course which the end user is studying on had a direct effect on voluntariness, NBMC, relative advantage, and ease of use. It was also found that the image the user gains by using spreadsheets had a direct effect on subjective norm, NBMC, and enjoyment.

User training was found to have a direct effect on usage and an indirect effect through voluntariness. EUC support was found to have a direct effect on relative advantage and NBMC. EUC experience was found only to have a positive direct effect on attitudes toward using spreadsheets.

The results also showed that compatibility had a direct effect on relative advantage, enjoyment, ease of use, and usage. It also showed that spreadsheets rating had a direct effect on ease of use, user satisfaction, and usage.

The data was analysed to determine which of these contributing factors has the most influence on usage. Total effect is considered as the proper indicator for identifying the relative influence of each contributing factor. Accordingly, attitude, compatibility, spreadsheets rating, relative advantage, ease of use, enjoyment, and training constitute the most influential factors upon spreadsheets usage. The same factors without attitude and training constitute the most influential factors to end-user satisfaction with spreadsheets.

The results of this study demonstrate the usefulness of investigating the factors that contribute to acceptance of spreadsheets (usage and satisfaction). Correlation and multiple regression analysis, path analysis, and LISREL modelling were used to examine the factors affecting user acceptance of spreadsheets. This study examined the external factors affecting beliefs about spreadsheets and beliefs in the workplace which in turn affect attitudes toward using and subjective norms respectively, and ultimately both attitudes and subjective norms affect usage.

Theoretical Significance of The Findings

The major implication of the findings to theory is that user acceptance of information technology can best be predicted from two general classes of factors: attitudes and subjective norms. Behavioural research has identified the importance of both aspects. In particular, IS research has shown the importance of attitudes towards acceptance of IT. This study delineates the importance of the subjective norms aspect in this context.

A second implication for theory, which could be related to the above, is that attitude towards using IT can, in the most part, be predicted from users' beliefs and perceptions about the IT characteristics. This study found that users with positive beliefs and perceptions regarding an IT as relatively advantageous, enjoyable, and easy to use had strong positive attitudes toward using it. On the other hand, subjective norms can be predicted from normative beliefs and motivation to comply, usage policies, and image associated with the IT product in the workplace.

A third implication for theory is that the set of individual, organisational, and IT characteristics act as the external stimuli in forming users' perceptions and norms in the workplace. This study examined a number of external variables that belong to a subset of this set of characteristics. Gender, EUC experience, and type of course which the user was studying were examined as individual characteristics, with support and training as organisational characteristics, and compatibility as an IT characteristic. Aside from gender, this study suggests that these characteristics make important contribution to users' perceptions and norms in the workplace.

The research also has implications for IT designers. It suggests that if end-users perceive a product to be of higher characteristics rating and of better compatibility to the task at hand the more likely they are to accept it. This implies that systems designers should strive to make systems more advantageous (i.e., higher functionality), easy to use, and enjoyable for their prospective users.

Further, the research has implications for research methods. It demonstrates the benefits of using students with some experience in the world of industrial work as a sample. More importantly though, the research shows that causal models should be built to make explicit the relationships between variables. The analysis of factors affecting spreadsheets acceptance showed that causal models can be built and tested.

Strengths of The Study

This study showed several strengths. Firstly, the study used theory grounded in existing work in MIS and reference disciplines to advance the study of acceptance of new information technology.

Secondly, the research design managed to procure a good volume of data at a reasonable cost from a wide cross section of end users. The participants in this study had held a variety of functions in different industries, reflecting considerable heterogeneity within the end-user community.

Thirdly, the data analysis used a large base of data and applied both semi-sophisticated and sophisticated techniques to test the model. The analysis used a structural equation model (a causal model), rather than simply correlational hypotheses, and used regression and path analysis and LISREL to test the model. These analysis techniques were applied to the research data gradually. Starting with the least powerful correlation analysis, followed by the more powerful regression and path analysis, and finishing with the most powerful and sophisticated technique for structural modelling: LISREL. Each method contributed to the analysis with increasing power, as each method fed into the next.

Finally, it tested an integrated model and the network of multivariate relationships among those variables found to be consistent in explaining and predicting the acceptance and success of IT across studies.

Overall, the results of this study demonstrate that end-user acceptance of spreadsheets is a product of external factors (individual, organisational, and system rating), beliefs in the workplace, IT characteristics, subjective norms, and finally attitudes toward using it.

Limitations of The Study

In presenting the findings and drawing conclusions it should be noted that there are some limitations to the study. These are discussed subsequently. All constructs are measured through user self-report perceptions. Researchers in MIS are encouraged to find alternative measures to these perceptions. It can be argued that it would be appropriate to develop more direct and objective measures for the user acceptance of information technology.

Three constructs do not have a measure in the form of a formal scale or instrument, namely: training, support, and EUC experience. These were measured using composite or aggregate items which do not give them the property of an instrument. This meant that a reliability and validity analysis could not be carried out for these constructs, and as a consequence, a significant weakness is noted for these constructs.

The study model was found to be too large to be processed by the PC version of LISREL. Thus, due to lack of computational capacity, it was decided to reduce the measurement model. To do this, single-item (instead of multiple-item) scales were used for measuring several variables in the course of LISREL modelling. There might be some differences if the multiple-item scales (i.e., full measurement model) were used.

Thus, the findings of this study are therefore exploratory in nature and should be considered with some caution. It is suggested that a replication of this study is necessary using a different sample and full measurement model when LISREL is available to be applied using mainframe computers.

Implications for Management

The research identified several contributing factors and tested some important relationships that organisations can use to their advantage.

The key to increasing spreadsheets usage is to improve the attitudes of end users toward using them and to cultivate positive subjective norms for spreadsheets usage.

One clearly identified factor, for example, that can be used to directly improve usage is to provide more training through formal courses as well as information exchange sessions. Management should consider spending in this direction as an investment for the organisation's competitive advantage. Nelson (1991) contends that for organisations to become more competitive with the rest of the world, they need to view employees as assets whose value can be enhanced through education and training.

Cheney et al (1986) adopted a conceptual scheme for relating organisational context variables to EUC success (here user acceptance of spreadsheets). They categorised these variables as uncontrollable, partially controllable, and fully controllable. EUC training and support and EUC policies (e.g., standards and different usage policies whether voluntary or compulsory) were categorised as fully controllable variables. Attitudes toward EUC and expectations about EUC (i.e., norms in the work place) were among the partially controllable variables.

The results of this study are in full support of the categorisation of these variables according to this conceptual scheme. This gives a great opportunity for management to provide the necessary EUC training and support and enforce standards and policies in order to achieve higher degrees of user acceptance. Likewise, there is a need for management to cultivate a more suitable psychological climate for positive norms and attitudes toward using spreadsheets in the workplace.

Suggestions for Future Research

Five areas for further research were generated by the study:

1) This research suggests that the usage — satisfaction relationship is ambiguous and equivocal. The discussion in the previous chapter indicated relevant literature and presented some of the different views of MIS researchers regarding this relationship. This study has shown a strong positive correlation between satisfaction and usage but it failed to establish any direction of causality between them. Further research could aim to determine how these concepts are related and what the implications for management are as a consequence of such a relationship.

2) This research suggests that subjective norms are an important determinant of usage. This finding is concluded for the first time in the IS context and is consistent with the base theory (TRA), however, TAM failed to establish this as a conclusion. There is a very useful implication for management in this finding but more research is needed to confirm and further establish this link by investigating the possibility of other normative beliefs as antecedents to and predictors of subjective norms.

3) The thrust of this research was to investigate the influence of attitudes and subjective norms on usage behaviour. However, these two could themselves be influenced by the usage behaviour. For example, in regard to attitudes, a person who uses spreadsheets and is happy with it can develop positive

attitudes toward using it and visa versa. These non-recursive and other recursive (reciprocal) types of relationships have rarely been considered in MIS research. A better understanding of these would have very important implications for post-implementation strategies in the adoption of new information technology. Further research in these areas is therefore important and potentially fruitful.

4) This research suggests that relative advantage and compatibility are two separate constructs. It also suggests that image and compatibility are exogenous factors in the model of contributing factors to spreadsheets acceptance. More research might suggest otherwise to these findings which could provide different implications for management regarding these constructs and their relationships to other factors in the user acceptance model of IT.

5) Another direction for future research is to investigate the consequences of system usage. The implicit assumption in this study is that higher usage of spreadsheets will lead to better performance. In reference to the risks associated with end-users' systems (like spreadsheets) discussed in the previous chapter, this may not always be the case. This study concentrated on the 'quantity' of usage, regardless of how it affected performance. Further research can be directed specifically at the 'quality' of usage, i.e., usage that leads to better performance.

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Appendix A

Survey Questionnaire

General instructions

This questionnaire is targeted at those students who have spent sometime in industry (or other organisations) for training. They should have used **spreadsheets (S/S)** during that period whether they developed their own models or used those developed by others. **When answering the questions it should be done as if you were still on your year out in the sandwich placement.**

In this questionnaire, your opinions are sought on several matters related to **spreadsheets (S/S).** Please select the response that best indicates how you feel about each statement of the following questionnaire. **Do not linger with a particular statement, as your initial impression is required.**

Examples

Please circle the most appropriate position of each statement which correspond most closely to your desired response.

If you think that it is quite likely that ***The weather in Loughborough is cold in March*** your answer to this statement would be as follows according to the different key given:

Key 1

The weather in Loughborough is cold in March

1	2	3	4	5
Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree

Key 2

The weather in Loughborough is cold in March

1	2	3	4	5
Almost never	Some of the time	About half of the time	Most of the time	Almost always

Key 3

Please make a cross mark in the place that best describe your opinion

In March the weather in Loughborough is

	extremely	quite	neither	quite	extremely	
Warm	______ :	______ :	______ :	______ :	______	Cold

In giving your answers please remember the following:

1 Place your marks in the middle of spaces, not on the boundaries

Warm ______ : ______ : ______ : ______ : ______ Cold

CORRECT WRONG

2 Please answer all items - please do not omit any.

3 Do not put more than one cross mark or a circle on a single scale.

Please circle the most appropriate number of each statement which correspond most closely to your desired response.

		Strongly Disagree	Disagree	Uncertain	Agree	Strongly Agree
1	Using S/S improved the quality of some tasks of my work in industry	1	2	3	4	5
2	Using S/S gave me greater control over my work in industry.	1	2	3	4	5
3	Using S/S enabled me to accomplish some tasks more quickly.	1	2	3	4	5
4	Using S/S increased my productivity while working in industry.	1	2	3	4	5
5	Using S/S improved my job performance in some tasks of my work in industry.	1	2	3	4	5
6	Using S/S enhanced my effectiveness on some tasks of my work in industry.	1	2	3	4	5
7	Using S/S made it easier to do some tasks of my work in industry.	1	2	3	4	5
8	<u>Overall</u>, I found using S/S to be advantageous in various tasks of my work in industry.	1	2	3	4	5
9	Using S/S was compatible with all aspects of some tasks in my work in industry.	1	2	3	4	5
10	I think that using S/S fitted with the way I liked to do some tasks of my work in industry.	1	2	3	4	5
11	Using S/S fitted into some tasks of my work style while in industry.	1	2	3	4	5
12	I believe that S/S are cumbersome to use.	1	2	3	4	5
13	Learning to use S/S was easy for me.	1	2	3	4	5
14	Using S/S was often frustrating.	1	2	3	4	5
15	I believe that it was easy to get S/S to do what I want it to do while in industry.	1	2	3	4	5
16	It was easy for me to remember how to perform tasks using S/S.	1	2	3	4	5
17	While working in industry, my using S/S system required a lot of mental effort.	1	2	3	4	5
18	While working in industry, my interaction with S/S system was clear and understandable.	1	2	3	4	5
19	<u>Overall</u>, I believe that S/S system was easy to use.	1	2	3	4	5

	extremely unlikely	quite unlikely	neutral	quite likely	extremely likely
20 My use of S/S was voluntary (as opposed to required by my superiors or job description)	1	2	3	4	5
21 My boss did <u>NOT</u> require me to use S/S.	1	2	3	4	5
22 Although it might be helpful, using S/S was certainly <u>NOT</u> compulsory in my work in industry	1	2	3	4	5
23 Based on my industrial experiences, I believe using S/S to be enjoyable.	1	2	3	4	5
24 The actual process of using S/S is pleasant.	1	2	3	4	5
25 While working in industry, I had fun using S/S.	1	2	3	4	5
26 People in my employing organisation who use S/S have more prestige than those who do not.	1	2	3	4	5
27 People in my employing organisation who use S/S have a high profile.	1	2	3	4	5
28 Using S/S was a status symbol in my employing organisation.	1	2	3	4	5
29 Most People in my employing organisation thought I should use S/S.	1	2	3	4	5
30 The people I worked closely with thought I should use S/S.	1	2	3	4	5
31 Generally speaking, I wanted to do what most people in my employing organisation thought I should do.	1	2	3	4	5
32 Generally speaking, I wanted to do what the people I worked closely with thought I should do.	1	2	3	4	5
33 Most people who were important to me thought I should use S/S.	1	2	3	4	5

Please make a cross mark in the place that best describe your opinion

34 **<u>All things considered,</u> my using spreadsheets in accomplishing various tasks in industry was:**

	extremely	*quite*	*neither*	*quite*	*extremely*		For office use
Bad	______	:______	:______	:______	:______	Good	
Foolish	______	:______	:______	:______	:______	Wise	
Unfavourable	______	:______	:______	:______	:______	favourable	
Harmful	______	:______	:______	:______	:______	Beneficial	
Negative	______	:______	:______	:______	:______	Positive	

35 **Please circle the number that corresponds to your best description of *spreadsheet system (S/S)*:**

1 = Almost never
2 = Some of the time
3 = About half of the time
4 = Most of the time
5 = Almost always

	Never				Always
Did S/S provide the precise information you need?	1	2	3	4	5
Did the S/S information content meet your needs?	1	2	3	4	5
Did the S/S provide reports that seem to be just about exactly what you need?	1	2	3	4	5
Did the S/S provide sufficient information?	1	2	3	4	5
Was the S/S accurate?	1	2	3	4	5
Were you satisfied with the accuracy of the S/S?	1	2	3	4	5
Do you think the output was presented in a useful format?	1	2	3	4	5
Was the information clear?	1	2	3	4	5
Was the S/S user friendly?	1	2	3	4	5

36 On an average working day in industry that you used a computer, how much time have you spent using spreadsheets? (**please tick one box**)

Almost never	
Less than 1/2 hour	
From 1/2 - 1 hour	

1 - 2 hours	
2 - 3 hours	
More than 3 hours	

37 On average, how frequently did you use spreadsheets while working in industry? (**please tick one box**)

Less than once a month	
Once a month	
A few times a month	

A few times a week	
About once a day	
Several times a day	

38 For which of the following applications is your employing organisation using S/S? **(please tick boxes where S/S is used)**

1 Business Analysis/Planning	
2 Marketing	
3 Pricing/Quoting	
4 Accounting/Financial Analysis	
5 Budgeting	
6 Personnel	
7 Forecasting	
8 Purchasing	
9 Production planning/Scheduling	
10 Stock Control	
11 Other	
12	
13	

39 For each spreadsheet package listed below indicate your level of usage (or None) while working in industry:

	None				Extremely extensive
LOTUS 1-2-3	1	2	3	4	5
SUPERCALC	1	2	3	4	5
QUATTRO PRO	1	2	3	4	5
EXCEL	1	2	3	4	5
SYMPHONY	1	2	3	4	5
Other - ____________	1	2	3	4	5
____________	1	2	3	4	5

For office use

40 How many different S/S applications have you worked with or used in industry? (**please tick one box**)

Just One application	
Two applications	
3 to 5 applications	
6 to 10 applications	
More than 10 applications	

41 For those S/S package(s) I have worked with or used, I would rate the overall characteristics to be:

	Poor		Average		Excellent
LOTUS 1-2-3	1	2	3	4	5
SUPERCALC	1	2	3	4	5
QUATTRO PRO	1	2	3	4	5
EXCEL	1	2	3	4	5
SYMPHONY	1	2	3	4	5
Other - (specify)________	1	2	3	4	5
________	1	2	3	4	5

For office use

42 What is the level of sophistication (using macros, menus, data validation, etc.) of the S/S applications that you have worked with or used?

Least sophisticated ... Highly sophisticated

1 2 3 4 5

43 Please indicate the extent to which each of the following contributed to the increase of your S/S knowledge and expertise during your industrial placement:

	None				Extremely extensive
A trainee explained features	1	2	3	4	5
A member of staff explained features	1	2	3	4	5
A S/S expert explained features	1	2	3	4	5
A central S/S expert explained features	1	2	3	4	5
A course on S/S package features	1	2	3	4	5
A course on S/S model building	1	2	3	4	5
A course on S/S advanced features	1	2	3	4	5
Through a tutorial package	1	2	3	4	5
Through self study	1	2	3	4	5
Other (specify) ____________________	1	2	3	4	5
____________________	1	2	3	4	5

For office use

The next section is used to assess the computing support you were provided with in your area during your industrial placement.

44 Which of the following category or categories best indicate the type and level of support on spreadsheets (S/S) you were provided with:

	None				Extremely extensive
Manuals	1	2	3	4	5
Online help	1	2	3	4	5
Tutorial package	1	2	3	4	5
Another trainee	1	2	3	4	5
Member of staff in your area	1	2	3	4	5
S/S expert in your area	1	2	3	4	5
Central S/S expert	1	2	3	4	5
Hotline to S/S expert	1	2	3	4	5
Other (specify) ____________________	1	2	3	4	5
____________________	1	2	3	4	5

For office use

45 Please circle the one number of each statement that best describes the level of general computing support in your employing organisation:

1 = Almost never
2 = Some of the time
3 = About half of the time
4 = Most of the time
5 = Almost always

		Never				Always
1	There was a person available to whom computer users could turn to for help	1	2	3	4	5
2	A central support was available to help with computer problems	1	2	3	4	5
3	Training courses were readily available for us to improve our computing abilities	1	2	3	4	5
4	Management provided most of the necessary help and resources for computing	1	2	3	4	5
5	Management was really keen to see that we were satisfied with use of our computers	1	2	3	4	5

The next set of questions assesses the actual experience you have working with computers and your experience in using spreadsheet packages:

For office use

46 How long have you used computers? ____ years

47 Have you ever written programs in a computer language? Yes / No

If Yes, for how long? ____ years

48 How long have you used spreadsheet packages? ____ years

		Low				High
49	Describe your current skill level with spreadsheets	1	2	3	4	5

50 Have you ever used other packaged application software? Yes / No

If Yes, please indicate the level of each used:

	None				Extremely extensive
WORD PROCESSING	1	2	3	4	5
DATABASES	1	2	3	4	5
GRAPHICS	1	2	3	4	5
MODELLING	1	2	3	4	5
CAD / CAE	1	2	3	4	5
Other, ____________	1	2	3	4	5
____________	1	2	3	4	5

For office use

51 In which department or type of department are you registered at LUT?

1	Business School	
2	A Science Department	
3	An Engineering Department	
4	Computer / Information & Library Studies	
5	Other, ____________	

52 Gender:

1	Male	
2	Female	

Please return this form to Mr Said Al-Gahtani in room B2.07, Brockington Building.

There will be a small reward for every completed form

Appendix B

SUMMARISED ANALYSIS OF RESPONSES BY QUESTION

SURVEY RESPONSES

	%Disagree	%Uncertain	%Agree
Q.1 S/S improved work quality	1	2	97
Q.2 S/S gave greater control over work	3	19	78
Q.3 S/S enabled to accomplish work more quickly	2	2	96
Q.4 S/S increased productivity	1	15	84
Q.5 S/S improved performance	2	11	87
Q.6 S/S enhanced effectiveness	2	12	86
Q.7 S/S made work easier	3	3	94
Q.8 Overall, S/S was found to be advantageous in work	1	3	96
Q.9 S/S was compatible with all aspects of the work	27	40	33
Q.10 S/S fitted the way I liked to do my work	3	21	76
Q.11 S/S fitted into my work style	3	16	81
Q.12 S/S were cumbersome to use	84	12	4
Q.13 Learning to use S/S was easy	10	10	80
Q.14 Using S/S was frustrating	24	19	57
Q.15 Getting S/S to do what I want	12	29	59
Q.16 It was easy to remember S/S commands	12	11	77

	%Disagree	%Uncertain	%Agree
Q.17 Using S/S required a lot of mental efforts	22	26	52
Q.18 Interaction with S/S was clear and understandable	3	26	71
Q.19 Overall, S/S was easy to use	3	10	87

	%Unlikely	%Neutral	%Likely
Q.20 Using S/S was voluntary	42	20	38
Q.21 Boss did not require S/S use	65	15	20
Q.22 Using S/S was not compulsory	48	12	40
Q.23 Using S/S was enjoyable	6	29	65
Q.24 Using S/S was pleasant	9	38	53
Q.25 I had fun using S/S	11	41	45
Q.26 S/S users have more prestige	48	33	19
Q.27 S/S users have a high profile	48	40	12
Q.28 Using S/S was a status symbol	65	26	9
Q.29 Most people in my organisation thought I should use S/S	14	24	63
Q.30 The people I worked closely with thought I should use S/S	10	20	70
Q.31 I wanted to do what most people in my organisation thought I should do	20	35	45
Q.32 I wanted to do what the people I worked closely with thought I should do	11	20	69
Q.33 Most people who were important to me thought I should use S/S	20	33	47

Q.(34 - 38) My using S/S in accomplishing tasks in industry was(%):

	extremely	quite	neither	quite	extremely	
Bad		1	3	67	29	Good
Foolish		1	10	59	30	Wise
Unfavourable	1	1	7	61	30	favourable
Harmful		1	5	44	50	Beneficial
Negative	1	1	5	55	38	Positive

	%Never	% 1/2 the time	%Always
Q.39 S/S provided precise information	9	21	70
Q.40 S/S information met my needs	7	22	71
Q.41 S/S provided reports that I need	14	30	56
Q.42 S/S provided sufficient information	7	23	70
Q.43 S/S was accurate	2	8	90
Q.44 I am satisfied with S/S accuracy	3	6	91
Q.45 S/S output presented in a useful format	5	16	79
Q.46 S/S provided by S/S was clear	4	12	84
Q.47 S/S was a user friendly	6	26	68

(Spreadsheets Daily Use)

Q.48 Almost never	3%
Q.49 Less than 1/2 hour	12%
Q.50 From 1/2 - 1 hour	25%
Q.51 1 - 2 hours	22%
Q.52 2 - 3 hours	17%
Q.53 More than 3 hours	22%

(Spreadsheets Usage Frequency)

Q.54 Less than once a month	3%
Q.55 Once a month	4%
Q.56 A few times a month	14%
Q.57 A few times a week	32%
Q.58 About once a day	17%
Q.59 Several times a day	31%

(Applications employing spreadsheets in industry)

Q.60 Business Analysis/Planning	66%
Q.61 Marketing	36%
Q.62 Pricing/Quoting	40%
Q.63 Accounting/Financial Analysis	70%
Q.64 Budgeting	59%
Q.65 Personnel	32%
Q.66 Forecasting	57%
Q.67 Purchasing	29%
Q.68 Production planning/Scheduling	37%
Q.69 Stock Control	32%
Q.70 - Q.72 Other applications	19%

(Spreadsheets packages used industry)

Q.71 LOTUS 1-2-3	73%
Q.72 SUPERCALC	19%
Q.73 QUATRO PRO	18%
Q.74 EXCEL	60%
Q.75 SYMPHONY	7%
Q.76 - 77 Other	7%

(Number of S/S applications used by end users in industry)

Q.78 Just 1 application	35%
Q.79 2 applications	31%
Q.80 3 to 5 applications	28%
Q.81 6 to 10 applications	3%
Q.82 More than 10 applications	3%

(Spreadsheets packages rating as perceived by end users)

	%Poor	% Average	Excellent
Q.83 LOTUS 1-2-3	3	18	52
Q.84 SUPERCALC	5	9	5
Q.85 QUATRO PRO	1	7	11
Q.86 EXCEL	2	5	53
Q.87 SYMPHONY	1	4	2

Q.90 Spreadsheets applications sophistication level

Least sophisticated	3%
Below average	10%
Average	29%
Above average	43%
Highly sophisticated	15%

(Sources of spreadsheets training and extent of contribution in industry)

	%Almost none	% Average	%Extensive
Q.91 A trainee	55	20	25
Q.92 A member of staff	33	22	45
Q.93 Local S/S expert	70	11	19
Q.94 Central S/S expert	81	12	7
Q.95 Course on package features	65	9	26

	%Almost none	% Average	%Extensive
Q.96 Course on S/S model building	85	9	6
Q.97 Course on S/S advanced features	83	5	12
Q.98 Through a tutorial package	53	18	29
Q.99 Through self study	10	12	78

(Sources of organisational support for spreadsheets application development and level of support in industry)

	%Almost none	% Average	%Extensive
Q.100 Manuals	20	22	58
Q.101 Online help	33	21	46
Q.102 Tutorial package	46	23	31
Q.103 Another trainee	57	20	23
Q.104 Member of staff	28	22	50
Q.105 Local S/S expert	70	15	15
Q.106 Central S/S expert	76	14	10
Q.107 Hotline to S/S expert	76	12	12

(Management and general EUC support for end users in industry)

	%Never	% 1/2 the time	%Always
Q.108 Person available for help	11	14	75
Q.109 Central support available	20	13	67
Q.110 Computer training courses available	42	22	36
Q.111 Management provided most of the necessary help for computing	44	26	30
Q.112 Management keen for user satisfaction	35	29	36

(EUC experiences)

Q.113 Writing programmes in computer languages?

No	54%
Yes	46%

	1 Year	2Years	3-5Years	6-10Years	>10 Years
Q.114 General computing	3%	5%	44%	43%	5%
Q.115 Programming	10%	13%	13%	8%	2%
Q.116 Using spreadsheets	14%	17%	61%	8%	—

Q.117 End users' current skill level with spreadsheets:

Low	9%
Average	30%
High	61%

(Using packaged application software)

	%Almost none	% Average	%Extensive
Q.119 Word processing	2	14	84
Q.120 Databases	38	28	34
Q.121 Graphics	30	22	48
Q.122 Modelling	75	12	13
Q.123 CAD/CAE	69	12	19

(Type of course/programme the student is studying in LUT)

Q.126 Business	59%
Q.127 Engineering	34%
Q.128 Sciences	7%

Q.129 Student gender

Male	68%
Female	32%

Appendix C

--------------- **FACTOR ANALYSIS** ---------------

Analysis number 1 Listwise deletion of cases with missing values

Extraction 1 for analysis 1, Maximum Likelihood (ML)

Initial Statistics:

Variable	Communality	*	Factor	Eigenvalue	Pct of Var	Cum Pct
		*				
V1	.45731	*	1	10.27213	20.1	20.1
V2	.39886	*	2	3.90501	7.7	27.8
V3	.48169	*	3	2.69023	5.3	33.1
V4	.55973	*	4	2.39809	4.7	37.8
V5	.46539	*	5	2.25676	4.4	42.2
V6	.43381	*	6	1.82595	3.6	45.8
V7	.37787	*	7	1.58046	3.1	48.9
V8	.48180	*	8	1.46616	2.9	51.8
V9	.42688	*	9	1.40057	2.7	54.5
V10	.52386	*	10	1.31594	2.6	57.1
V11	.42699	*	11	1.22839	2.4	59.5
V12	.55874	*	12	1.13034	2.2	61.7
V13	.39623	*	13	1.06311	2.1	63.8
V14	.28201	*	14	.99646	2.0	65.7
V15	.50093	*	15	.91961	1.8	67.5
V16	.40129	*	16	.88268	1.7	69.3
V17	.24791	*	17	.83371	1.6	70.9
V18	.36398	*	18	.81601	1.6	72.5
V19	.64047	*	19	.79168	1.6	74.1
V20	.51736	*	20	.75267	1.5	75.5
V21	.53234	*	21	.72953	1.4	77.0
V22	.54222	*	22	.71320	1.4	78.4
V23	.65142	*	23	.66274	1.3	79.7
V24	.62868	*	24	.61800	1.2	80.9
V25	.59679	*	25	.61401	1.2	82.1
V26	.66721	*	26	.59524	1.2	83.3
V27	.74256	*	27	.57294	1.1	84.4
V28	.61408	*	28	.55156	1.1	85.5
V29	.67254	*	29	.50868	1.0	86.5
V30	.70186	*	30	.47889	.9	87.4
V31	.54258	*	31	.46789	.9	88.3
V32	.57972	*	32	.46380	.9	89.2
V34	.41125	*	33	.44056	.9	90.1
V35	.44618	*	34	.42792	.8	90.9
V36	.46357	*	35	.40433	.8	91.7
V37	.38726	*	36	.37447	.7	92.5
V38	.50078	*	37	.37070	.7	93.2
V39	.38723	*	38	.35144	.7	93.9
V40	.50870	*	39	.32267	.6	94.5
V41	.43062	*	40	.31603	.6	95.1

V42	.47995	*	41	.30753	.6	95.7
V43	.71704	*	42	.29226	.6	96.3
V44	.73224	*	43	.28023	.5	96.8
V45	.57095	*	44	.27605	.5	97.4
V46	.58312	*	45	.24933	.5	97.9
V47	.44149	*	46	.22621	.4	98.3
DAY_USE	.64275	*	47	.20710	.4	98.7
FREQ_USE	.66882	*	48	.19438	.4	99.1
USE_LVL	.46918	*	49	.17621	.3	99.5
V82	.37585	*	50	.14677	.3	99.7
NOSS_APP	.20009	*	51	.13338	.3	100.0

Factor scree plot (plot attached at the end)

ML attempted to extract 13 factors.

More than 25 iterations required. Convergence = .03166

Factor Matrix:

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
V30	.99945					
V29	.75645					
V32	.46627					
V43		.78365				
V44		.73529				
V45		.52138		-.44396		
V10		.45667				
V24		.43554				
V25		.42993				
V23		.42653				
V40		.40497				
V47		.40392				
V34						
V41						
V4						
V1						
V36						
V82						
V2						
V7						
V39						
V16						
V35						
V37						
V18						

V27			.74990	-.47421		
V28			.61281			
V26			.60052	-.40083		
V9						
FREQ_USE				.44536		
V19		.41388		.43132		
V12						
V13						
USE_LVL						
DAY_USE						
V46		.56351			-.71892	
V22						.59206
V20						.59100
V21						.53580
V31						
V15						
V6						
V14						
V17						
V3						
V8						
V5						
V42						
NOSS_APP						
V38						
V11						

	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12
V30						
V29						
V32	.40309					
V43						
V44						
V45						
V10						
V24						
V25						
V23						
V40						
V47						
V34						

V41					
V4					
V1					
V36					
V82					
V2					
V7					
V39					
V16					
V35					
V37					
V18					
V27					
V28					
V26					
V9					
FREQ_USE					
V19					
V12					
V13					
USE_LVL					
DAY_USE					
V46					
V22					
V20					
V21					
V31	.46987	.43522			
V15					
V6					
V14					
V17					
V3					
V8					
V5					
V42					
NOSS_APP					
V38					-.46248
V11					

	Factor 13
V30	

V29	
V32	
V43	
V44	
V45	
V10	.41156
V24	
V25	
V23	
V40	
V47	
V34	
V41	
V4	
V1	
V36	
V82	
V2	
V7	
V39	
V16	
V35	
V37	
V18	
V27	
V28	
V26	
V9	
FREQ_USE	
V19	
V12	
V13	
USE_LVL	
DAY_USE	
V46	
V22	
V20	
V21	
V31	
V15	
V6	
V14	
V17	
V3	
V8	
V5	
V42	

NOSS_APP

V38

V11

Final Statistics:

Variable	Communality	*	Factor	SS Loadings	Pct of Var	Cum Pct
		*				
V1	.34330	*	1	3.86136	7.6	7.6
V2	.32698	*	2	6.09200	11.9	19.5
V3	.54273	*	3	2.84239	5.6	25.1
V4	.55769	*	4	3.11167	6.1	31.2
V5	.44950	*	5	1.37080	2.7	33.9
V6	.39425	*	6	1.87120	3.7	37.5
V7	.34529	*	7	1.79933	3.5	41.1
V8	.47154	*	8	1.31402	2.6	43.7
V9	.36619	*	9	1.37385	2.7	46.3
V10	.62268	*	10	1.11324	2.2	48.5
V11	.41862	*	11	.87262	1.7	50.2
V12	.58555	*	12	.83546	1.6	51.9
V13	.37948	*	13	.63360	1.2	53.1
V14	.20832 *					
V15	.46494 *					
V16	.31014 *					
V17	.16137 *					
V18	.31402 *					
V19	.69688 *					
V20	.64719 *					
V21	.59579 *					
V22	.62454 *					
V23	.68902 *					
V24	.70360 *					
V25	.67413 *					
V26	.66722 *					
V27	.92231 *					
V28	.58670 *					
V29	.61935 *					
V30	.99900 *					
V31	.72225 *					
V32	.65284 *					
V34	.38572 *					
V35	.44392 *					
V36	.43022 *					
V37	.37064 *					
V38	.64337 *					
V39	.41260 *					
V40	.54809 *					
V41	.40379 *					
V42	.51525 *					
V43	.94194 *					
V44	.72993 *					

V45	.53877	*
V46	.90169	*
V47	.38082	*
DAY_USE	.69929	*
FREQ_USE	.74939	*
USE_LVL	.46894	*
V82	.34839	*
NOSS_APP	.11623	*

VARIMAX rotation 1 for extraction 1 in analysis 1 - Kaiser Normalization.

VARIMAX converged in 8 iterations.

Rotated Factor Matrix:

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
V4	.68279					
V3	.64115					
V8	.64020					
V5	.58170					
V7	.52831					
V6	.52699					
V1	.44844					
V2	.41941					
V19		.76966				
V12		.71709				
V15		.58628				
V13		.54796				
V16		.50506				
V18		.45126				
V47		.43133				
V14						
V17						
V27			.94035			
V26			.78455			
V28			.71193			
FREQ_USE				.72952		
DAY_USE				.70667		
USE_LVL				.58346		
V82				.46093		
NOSS_APP						
V24					.72497	
V25					.72027	
V23					.66391	
V20						.79235
V22						.74273
V21						.71338

V42
V40
V39
V41

V38
V35
V36
V37
V34

V43
V44

V46
V45

V31
V32

V30
V29

V10
V11
V9

V4
V3
V8
V5
V7
V6
V1
V2

V19
V12
V15
V13
V16
V18
V47
V14
V17

V27
V26
V28

FREQ_USE
DAY_USE
USE_LVL
V82
NOSS_APP

	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12
V24						
V25						
V23						
V20						
V22						
V21						
V42	.66405					
V40	.65410					
V39	.59333					
V41	.52838					
V38		.73859				
V35		.53656				
V36		.48822				
V37		.44571				
V34						
V43			.91627			
V44			.75259			
V46				.90704		
V45				.63460		
V31					.80492	
V32					.72551	
V30						.88355
V29						.62585
V10						
V11						
V9						
V4						
V3						
V8						
V5						
V7						
V6						
V1						
V2						
V19						
V12						
V15						
V13						
V16						
V18						
V47						

V14
V17

V27
V26
V28

FREQ_USE
DAY_USE
USE_LVL
V82
NOSS_APP

V24
V25
V23

V20
V22
V21

V42
V40
V39
V41

V38
V35
V36
V37
V34

V43
V44

V46
V45

V31
V32

V30
V29

<u>Factor 13</u>

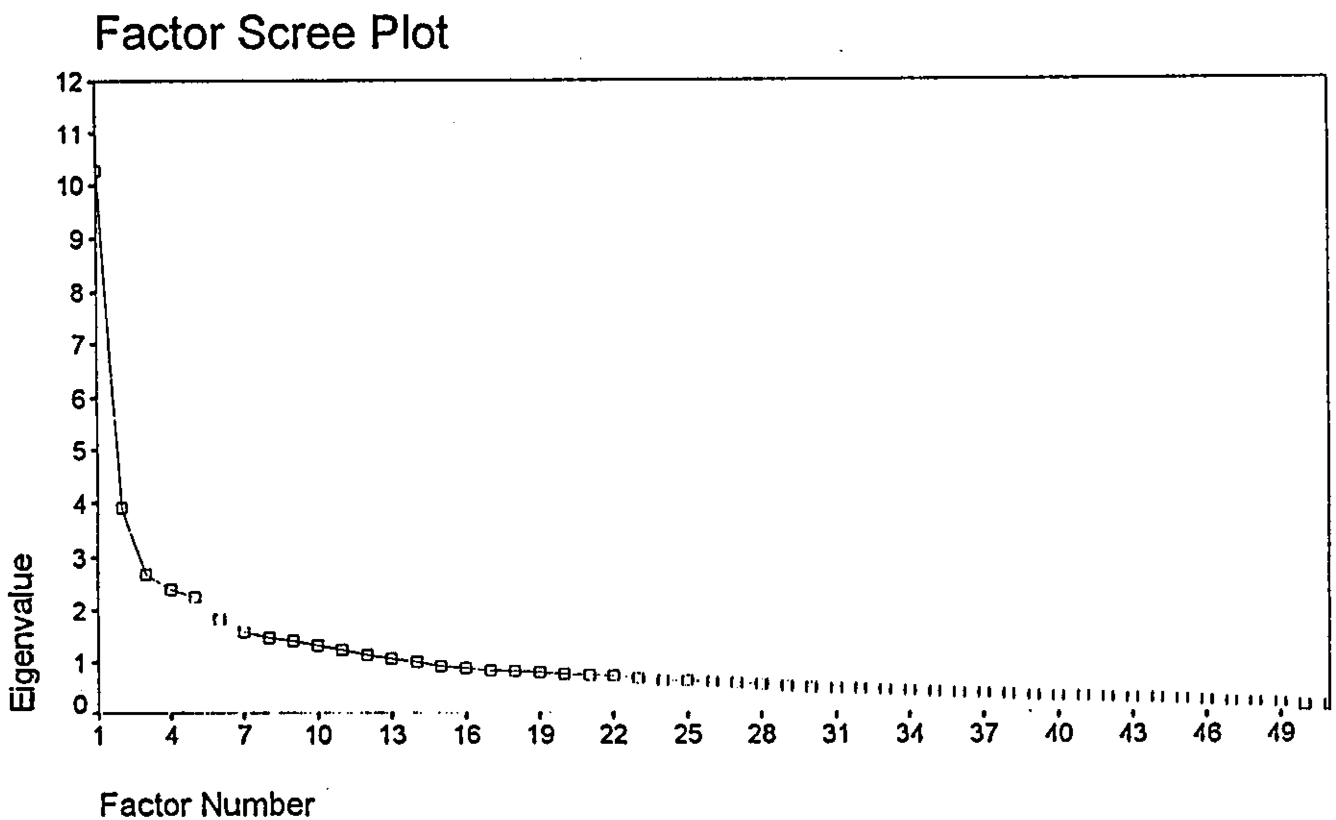
V10	.55969
V11	.47301
V9	

Factor Transformation Matrix:

	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Factor 1	.20055	.04682	.13467	.12651	.11101	-.22980
Factor 2	.31460	.30738	.17638	.15215	.22860	.07062
Factor 3	.16011	.12898	.77125	.16481	.18856	-.04942
Factor 4	.20177	.41547	-.55487	.35721	.22245	-.12945
Factor 5	.19833	.05831	-.09685	.25073	-.00236	-.07548
Factor 6	-.12170	.30584	-.02223	-.30939	.33188	.74138
Factor 7	.34294	-.50039	-.18459	-.13139	.44845	.10854
Factor 8	-.24335	.37047	-.02587	-.32074	.04881	-.38175
Factor 9	.60250	.02482	-.01496	-.40782	-.52592	.09307
Factor 10	.21737	-.33225	-.02100	.03653	.24172	-.10545
Factor 11	-.08560	-.10692	.00405	.59370	-.37798	.42116
Factor 12	.37113	.31940	-.02848	-.02884	-.14978	.07597
Factor 13	-.09039	-.07096	-.04402	-.07995	-.19084	-.08494

	Factor 7	Factor 8	Factor 9	Factor 10	Factor 11	Factor 12
Factor 1	.06189	.10576	.03878	-.01286	.24894	.88004
Factor 2	.27481	.19819	.61914	.37014	-.05610	-.20622
Factor 3	-.11171	.08853	-.44274	-.15510	.03161	-.22292
Factor 4	-.00709	.19860	-.46843	.08818	-.07206	-.08380
Factor 5	-.07545	.01881	.34746	-.84327	-.19283	-.05628
Factor 6	.14543	-.00292	-.09780	-.22510	-.04414	.20668
Factor 7	-.22334	.15886	.03220	-.05062	.50145	-.18481
Factor 8	.36867	.00700	.02476	-.22265	.55916	-.19995
Factor 9	.19296	.31649	-.17432	-.04912	-.04808	-.00915
Factor 10	.68678	-.46460	-.18188	-.04590	-.21892	-.01609
Factor 11	.29363	.02920	-.04648	-.03340	.46220	-.05307
Factor 12	-.30916	-.74615	.04604	.06873	.24755	-.02194
Factor 13	.06908	.05479	-.00569	-.08203	.01733	-.05120

	Factor 13
Factor 1	.07204
Factor 2	.11929
Factor 3	.08165
Factor 4	.07772
Factor 5	-.03296
Factor 6	.09787
Factor 7	.05874
Factor 8	-.11433
Factor 9	-.10945
Factor 10	.01193
Factor 11	-.04140
Factor 12	.09736
Factor 13	.95780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Eigenvalue
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Appendix D

****** RELIABILITY ANALYSIS FOR 10 SCALES ******

RELIABILITY ANALYSIS - SCALE (REL_ADV)

N of Cases = 333.0

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	4.2492	3.9369	4.5435	.6066	1.1541	.0406
Item Variances	.4458	.3523	.5312	.1789	1.5078	.0051
Inter-item Correlations	.3703	.2598	.5078	.2480	1.9544	.0052

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item- Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
V1	29.6517	10.4205	.5230	.2921	.8069
V2	30.0571	10.0901	.4709	.2509	.8148
V3	29.4505	10.3326	.5141	.3072	.8078
V4	29.8529	9.2765	.6688	.4701	.7850
V5	29.8709	9.8357	.5553	.3676	.8022
V6	29.8829	9.8929	.5480	.3370	.8033
V7	29.5856	10.2735	.4990	.2753	.8097
V8	29.6066	10.1068	.5942	.3784	.7978

Reliability Coefficients 8 items

Alpha = .8239 Standardized item alpha = .8247

RELIABILITY ANALYSIS - SCALE (COMPATIBILITY)

N of Cases = 333.0

Item Means	Mean	Minimum	Maximum	Range	Max/Min	Variance
	3.6026	3.0781	3.8739	.7958	1.2585	.2064

Item Variances	Mean	Minimum	Maximum	Range	Max/Min	Variance
	.5801	.4118	.8252	.4135	2.0041	.0472

Inter-item Correlations	Mean	Minimum	Maximum	Range	Max/Min	Variance
	.4251	.2856	.5422	.2566	1.8982	.0135

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
V9	7.7297	1.4087	.4219	.2029	.7009
V10	6.9520	1.5700	.6021	.3872	.4242
V11	6.9339	1.9053	.4667	.2963	.6055

Reliability Coefficients 3 items

Alpha = .6697 Standardized item alpha = .6893

RELIABILITY ANALYSIS - SCALE (EASE OF USE)

N of Cases = 333.0

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	3.7042	3.3033	4.0120	.7087	1.2145	.0734
Item Variances	.6332	.3370	1.0364	.6993	3.0749	.0568
Inter-item Correlations	.3103	.0666	.6586	.5920	9.8952	.0178

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
V12	25.6216	11.6335	.5792	.4808	.7136
V13	25.7447	11.3774	.5040	.2966	.7253
V14	26.2312	11.5156	.3697	.1720	.7584
V15	26.1291	11.3417	.5709	.3863	.7129
V16	25.8108	12.1539	.4647	.2884	.7332
V17	26.3303	12.7701	.2324	.0693	.7793
V18	25.9189	12.7735	.4809	.2482	.7348
V19	25.6486	12.1382	.6326	.5277	.7136

Reliability Coefficients 8 items

Alpha = .7596 Standardized item alpha = .7826

RELIABILITY ANALYSIS - SCALE (VOLUNTARINESS)

N of Cases = 333.0

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	2.6677	2.2913	2.8919	.6006	1.2621	.1075
Item Variances	1.6065	1.5063	1.7807	.2743	1.1821	.0229
Inter-item Correlations	.5993	.5838	.6081	.0242	1.0415	.0001

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
V20	5.1111	5.3220	.6638	.4408	.7549
V21	5.7117	5.2721	.6655	.4430	.7530
V22	5.1832	4.8127	.6821	.4653	.7372

Reliability Coefficients 3 items

Alpha = .8172 Standardized item alpha = .8177

RELIABILITY ANALYSIS - SCALE (ENJOYMENT)

N of Cases = 333.0

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	3.4965	3.3423	3.6757	.3333	1.0997	.0282
Item Variances	.6616	.5873	.8041	.2168	1.3692	.0153
Inter-item Correlations	.6631	.6322	.6987	.0665	1.1051	.0009

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
V23	6.8138	2.2966	.7274	.5404	.7883
V24	7.0180	2.2708	.7490	.5665	.7692
V25	7.1471	2.0054	.7002	.4916	.8226

Reliability Coefficients 3 items

Alpha = .8511 Standardized item alpha = .8552

RELIABILITY ANALYSIS - SCALE (IMAGE)

N of Cases = 333.0

Item Means	Mean	Minimum	Maximum	Range	Max/Min	Variance
	2.3894	2.1201	2.5706	.4505	1.2125	.0565

Item Variances	Mean	Minimum	Maximum	Range	Max/Min	Variance
	1.0501	.9310	1.2277	.2967	1.3187	.0246

Inter-item Correlations	Mean	Minimum	Maximum	Range	Max/Min	Variance
	.6863	.5956	.7615	.1659	1.2785	.0056

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
V26	4.5976	3.2713	.7341	.5872	.8246
V27	4.6907	3.5336	.8207	.6755	.7439
V28	5.0480	3.7868	.6872	.5016	.8599

Reliability Coefficients 3 items

Alpha = .8650 Standardized item alpha = .8678

RELIABILITY ANALYSIS - SCALE (NBMC)

N of Cases = 333.0

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	3.5435	3.2673	3.7237	.4565	1.1397	.0392

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Variances	.9016	.7728	1.1241	.3513	1.4546	.0245

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Inter-item Correlations	.4845	.2896	.7551	.4655	2.6069	.0307

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
V29	10.6276	5.3669	.5706	.5720	.7417
V30	10.4505	5.3387	.6516	.6057	.7038
V31	10.9069	5.1389	.5192	.4358	.7754
V32	10.5375	5.2795	.6413	.4969	.7073

Reliability Coefficients 4 items

Alpha = .7843 Standardized item alpha = .7899

RELIABILITY ANALYSIS - SCALE (ATTITUDE)

N of Cases = 333.0

	Mean	Minimum	Maximum	Range	Max/Min	Variance
Item Means	4.2595	4.1562	4.4354	.2793	1.0672	.0117
Item Variances	.4134	.2886	.4990	.2104	1.7293	.0061
Inter-item Correlations	.3854	.2708	.5137	.2429	1.8969	.0045

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
V34	17.0511	3.8980	.5021	.2562	.7249
V35	17.1411	3.4409	.5454	.3395	.7072
V36	17.1081	3.5786	.5061	.2575	.7215
V37	16.8619	3.7158	.4627	.2481	.7362
V38	17.0270	3.1890	.6198	.4007	.6777

Reliability Coefficients 5 items

Alpha = .7580 Standardized item alpha = .7582

RELIABILITY ANALYSIS - SCALE (EUCS)

N of Cases = 333.0

Item Means	Mean	Minimum	Maximum	Range	Max/Min	Variance
	3.9066	3.4955	4.3123	.8168	1.2337	.0737

Item Variances	Mean	Minimum	Maximum	Range	Max/Min	Variance
	.5780	.3522	.7735	.4213	2.1964	.0139

Inter-item Correlations	Mean	Minimum	Maximum	Range	Max/Min	Variance
	.2967	.1242	.8164	.6922	6.5750	.0186

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
V19	35.0811	19.1530	.3310	.2157	.8062
V39	35.3544	17.8620	.4358	.3172	.7970
V40	35.3363	17.4889	.5351	.4138	.7864
V41	35.5706	17.0771	.5003	.3234	.7901
V42	35.3574	17.3328	.5256	.3711	.7871
V43	34.7538	17.6922	.5108	.6736	.7891
V44	34.7688	17.3409	.5339	.6940	.7863
V45	35.0601	16.9361	.5313	.4979	.7863
V46	34.9940	17.5180	.5053	.4720	.7894
V47	35.3183	17.1755	.4493	.3343	.7971

Reliability Coefficients 10 items

Alpha = .8085 Standardized item alpha = .8084

RELIABILITY ANALYSIS - SCALE (USAGE)

N of Cases = 333.0

Item Means	Mean	Minimum	Maximum	Range	Max/Min	Variance
	3.7297	2.0721	4.5105	2.4384	2.1768	.9989

Item Variances	Mean	Minimum	Maximum	Range	Max/Min	Variance
	1.2421	.5037	2.0206	1.5170	4.0120	.4045

Inter-item Correlations	Mean	Minimum	Maximum	Range	Max/Min	Variance
	.3747	.1266	.7149	.5882	5.6448	.0348

Item-total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Alpha if Item Deleted
DAY_USE	14.6276	7.8850	.6902	.5507	.6249
FREQ_USE	14.1892	8.2683	.6978	.5591	.6197
USE_LVL	14.1381	12.0351	.5842	.3603	.7011
NOSS_APP	16.5766	12.8352	.2264	.0531	.7897
V82	15.0631	11.4328	.4705	.2479	.7168

Reliability Coefficients 5 items

Alpha = .7464 Standardized item alpha = .7498