DIFFUSION OF COMPUTER-AIDED SOFTWARE ENGINEERING IN ORGANIZATIONS: COMPLEMENTING CLASSICAL DIFFUSION THEORY WITH ORGANIZATIONAL LEARNING PERSPECTIVE

by

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Timely availability of high quality and reliable software is critical to successful use of information systems (IS). Unfortunately, software produced is typically late, over budget, and of poor quality. Computer-aided software engineering (CASE) has potential to improve productivity, cut cost, and eliminate quality problems of software development. However, contrary to the predictions of the existing theory of innovation diffusion, organizations are slow to adopt and implement it.

An inadequate conceptual and theoretical foundation of organizational innovation diffusion theory is a major cause for its inability to explain slow diffusion of CASE. Diffusion of innovations has been studied primarily using communications perspective, which has not been successful in explaining the organizational diffusion of complex information technology (IT) innovations, including CASE, CAD, CAM, and others. These technologies are characterized by high user interdependencies and knowledge barriers. Knowledge burden aspect suggests that complex IT innovations cannot be adopted as "black box" solutions but rather impose a substantial knowledge burden on potential adopters. Know-how to use such innovations has to be developed *in situ* and *de novo*, which requires both individual learning and organizational learning.

This study identifies the gaps in the IS literature on the organizational diffusion of IT innovations and models IT diffusion in organizations by integrating communications and organizational learning perspectives. It develops measures for many new constructs, refines measures for some old constructs, and using a survey methodology empirically identifies factors that significantly relate to the diffusion of CASE technology.

The results of this study show that size of IS department (ISD), organizational size, proportion of development project in ISD, and perceived capability of CASE are important variables in differentiating "adopters" and "non-adopters." The results also show that the level of adoption of CASE is significantly related to ISD size, organizational size, perceived technological characteristics of CASE (capability, efficiency, and stability), and organizational learning variables (turnover of technical IS personnel, environmental scanning, job/role rotation, and media richness of communication channels). The level of infusion is primarily related to organizational learning variables (turnover of technical IS personnel, job/role rotation, and media richness of communication channels).

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CHAPTER I
INTRODUCTION

This chapter provides a background for this study and discusses its relevance to information technology (IT) diffusion research. It describes the problem statement and objectives of this study, and provides an overview of subsequent chapters.

1.1 Background and Relevance of the Study

The potential of information technology (IT) to enhance the competitiveness of organizations is now rarely disputed. IT has become and is likely to remain a critical factor in the evolution of modern business practices. To a large degree, a firm's ability to exploit IT hinges on its ability to successfully develop, implement, and use increasingly complex and integrated information systems. Software is a major, and arguably the most important, component of any information system. Timely availability of high quality and reliable software is critical to the successful implementation of information systems. '... (A)ll precepts such as "using IT for strategic advantages," "reengineering the business," and "informating the workplace" become mere slogans if the necessary software is not properly developed on time.' (Fichman and Kemerer, 1993, p. 7) Ironically, software production has been and remains the single biggest obstacle to the successful use of information technology (Fichman and Kemerer, 1993).

1.1.1 Current State of Software Development in the Industry

The burden of acquiring, developing, implementing, and maintaining software and information systems in organizations rests on information systems departments (ISDs), which are increasingly hard pressed to deliver software and application systems of ever higher quality at reduced costs more quickly than ever. Unfortunately, software produced is late, over budget, and of poor quality, and information systems projects suffer from falling performance and increased backlogs, often as a result of increasing demands on ISDs. Alloway and Quillard (1983) estimated this backlog to be about 374 per cent of the existing capacity of ISDs to meet demand. According to a recent estimate, visible backlog stretches out as far as 30 months in some organizations, while the invisible backlog, which consists of applications that never get formally requested because of long lead times, may continue to swell (Stamps, 1987).

Poor quality of software has forced ISDs to spend almost seventy percent of their resources on maintenance resulting in less free resources for new systems development efforts (Bachman, 1988). The cyclic nature of this process -- poor quality resulting in increased spending on maintenance, more maintenance resulting in less resources available for new systems development efforts, less resources resulting in further increase in backlogs and poorer quality -- may eventually see all the resources consumed by maintenance activities. Similar views have been expressed by others (see Bachman, 1988).

In 1983, Alloway and Quillard argued that it would be impossible for information systems departments, end-user programming, or packaged software to satisfy the industry demand. One decade later, the same can be said about the state of software development. As a result, improved productivity through faster development tools and methods and better systems development management is of critical importance to the IS community (Jeffery, 1987).

1.1.2 Computer-Aided Software Engineering -- A Potential Solution

Computer-aided software engineering (CASE), a relatively recent technological innovation, is viewed by both researchers and practitioners as a potential means to increase the productivity of information systems development activities (Banker and Kauffman, 1991; Norman and Nunamaker, 1988; Stamps, 1987; Robinson, 1992; Swanson, et al., 1991) and ease the software development and maintenance burden threatening to overwhelm ISDs (Bachman, 1988; Banker and Kauffman, 1991; Robinson, 1992; Swanson, et al., 1991). It is believed to significantly improve the quality of information systems by redefining the systems development process through imposition of an engineering structure (Howard, 1990). It is also said to reduce cost of systems development and aid in enhancing the competitive position of an organization (Feuche, 1989; Martin, 1989)[1].

1.1.3 Slow Diffusion of CASE

Despite the touted advantages of using CASE, its diffusion has been slow. Many reasons have been put forth in the literature to account for the slow diffusion of CASE. Howard and Rai (1993) argue that uneven success of CASE has led many IS managers to delay implementation. Bachman (1988) questions the conceptual foundation of CASE

[1]It is important to note that while many studies have reported productivity gains (or perception of such gains) from the use of CASE tools (Banker and Kauffman, 1991; Necco, et al., 1989; Norman and Nunamaker, 1988; Swanson, et al., 1991), some have found that the expected productivity gains are elusive (Card, et al., 1987; Yellen, 1990), or marred by inadequate training and experience, developer resistance, and increased design and testing time (Norman, et al., 1989; Orlikowski, 1988, 1989; Vessey, et al., 1992).

and advocates its reexamination.

Fichman (1992) argues that the inadequate conceptual and theoretical foundations of organizational innovation diffusion may be a bigger culprit (Fichman, 1992). In this vein, some researchers (Orlikowski, 1993; Rai, 1995; Rai and Howard, 1993, 1994; Rai and Patnayakuni, 1996; Vipond, 1990; Wynekoop, 1991) have revisited conceptual and theoretical bases for the CASE adoption and implementation. While their studies significantly advance our understanding of CASE diffusion in organizations, they do not take into account many contingencies which may have significant impact on the course of CASE diffusion in organizations. For example, while Orlikowski (1993) conceptualizes adoption and use of CASE tools as a form of organizational change, she treats the tools themselves as unchanging. However, there is evidence that innovations and organizations mutually adapt to each other (Leonard-Barton, 1988; Van de Ven, 1986; Walton, 1989). Rai and Howard (1993, 1994), on the other hand, develop and empirically test a model, primarily based on the work by Kwon and Zmud (1987), that draws on past research on organizational innovation, IS implementation, and systems development to explain CASE diffusion. While their study helps to place diffusion of CASE innovation studies on an empirical footing, their primary reliance on communication perspective weakens the study at the cost of ignoring economic and market and infrastructure perspectives consideration of which may foretell an altogether different locus of CASE diffusion in organizations. Furthermore, recent research (Attewell, 1992) shows that organizational learning plays an important role in the diffusion of information technology innovations. Thus, it is important that future research on organizational innovation diffusion also considers organizational learning perspective.

1.2 Problem Statement and Research Objectives

From the above discussion, it can be concluded that there is a clear need to further reexamine the conceptual and theoretical bases of innovation diffusion in organizations. In this research effort, we have attempted to gain a better understanding of the CASE diffusion process primarily by working along the following lines of inquiry. First, we identify the gaps in the IS literature on organizational diffusion of technological innovations. Having identified the gaps, we then discuss the four different perspectives (communications, economic, market and infrastructure, and organizational learning) on technological diffusion in organizations and argue that integration of these perspectives is necessary to gain a more complete understanding of the process of organizational innovation diffusion. Towards this end we incorporate elements of both communications and organizational learning perspectives to model the diffusion of IT innovations in organizations.

Next, we test this model empirically using computer-aided software engineering (CASE) as an instance of IT innovations. In this phase of the research, we adopt (where possible), adapt (where amenable), develop (when the variable has been not operationalized previously), and validate instruments to measure different variables in our operational model. Using these instruments, a national mail questionnaire survey was conducted to collect data on the diffusion of CASE in organizations. The survey data is used to test the validity of the theoretical model and identify significant variables affecting the diffusion of CASE tools. The data is also used to profile user and non-user organizations of CASE.

In short, we accomplish the following objectives in this research effort:

1. Identify the gaps in the IS literature on the organizational diffusion of IT innovations;
2. Model the diffusion of IT innovations in organizations by drawing on communications and organizational learning perspectives;
3. Profile user and non-users of CASE; and
4. Identify factors that are significantly related to the diffusion of CASE in organizations through an empirical test of the theoretical model.

1.3 Outline of the Dissertation

The second chapter describes what an innovation is and what are its different variants. It identifies the gaps in the existing research on the diffusion of IT innovations in organizations through an in-depth review of the literature; and discusses the roles played by different perspectives in the diffusion of technological innovations in organizations and the necessity to integrate these perspectives to gain a broader understanding of innovation diffusion in organizations.

The third chapter describes the research model used in this study for empirical testing. It describes the innovation examined -- CASE technology, and discusses different diffusion phases examined in this study. It also describes the variables selected for the study, and discusses the hypotheses developed for empirical testing in the context of CASE diffusion in organizations.

The fourth chapter describes the research methodology used in this study. It discusses the rationale for the methodology used in this research (that is, mail survey), and describes the instrument development process and operationalization of various dependent and independent variables in the research model. It also describes the details of mail survey, and discusses the issues of reliability and validity for various constructs.

The fifth chapter describes the statistical analyses used in this study. These analyses are used to differentiate between user and non-user organizations of CASE, and to identify variables which significantly affect the diffusion of CASE technology in organizations. The results of the study are also interpreted in this chapter.

Finally, the sixth chapter concludes the results of this study. It identifies shortcomings and contributions of this study, and suggests future research directions.

CHAPTER II
LITERATURE REVIEW AND THEORETICAL FRAMEWORK

This chapter defines what an innovation is and describes its various types as found in the literature. Following this it briefly discusses classical diffusion theory, and reviews the IS literature in an attempt to identify gaps in the research on diffusion of IT innovations in organizations. Next, it reviews the shortcomings of classical diffusion theory and makes an argument that economic and market and infrastructure perspectives of innovation diffusion complement and extend the classical theory or communications perspective of organizational innovation diffusion. Based on recent research, then it establishes that organizational learning is a necessary part of successful adoption and implementation of a technology, particularly if the technology in question happens to be a complex one, such as CASE. Subsequently, it briefly reviews the organizational learning literature, and it makes an argument as to the necessity of combining all these perspectives to gain a fuller understanding of organizational innovation diffusion.

2.1 Innovation and Its Types

An innovation is an idea, practice, or object that is new to the adopting unit (Rogers, 1983). Innovations do not appear immediately everywhere once they become available. The process by which innovations spread from one locale or one social group to another is called diffusion (Brown, 1981).

2.1.1 Types of Innovation

Past research (see Downs and Mohr, 1976; Knight, 1967; Rowe and Boise, 1974) emphasizes the distinction between different types of innovations to better understand organizations' adoption behavior and identify its determinants. Among numerous typologies of innovations in literature, three are most widely accepted -- incremental and radical, administrative and technical, and product and process (Damanpour, 1991).

The adoption of an innovation by an organization can create changes in its structure and mode of functioning. Innovations can be classified according to the degree of change they make in the practices of adopting organization. Radical innovations bring out fundamental changes in the activities of an organization and represent clear departure from existing practices, while incremental innovations result in little departure from existing practices (Dewar and Dutton, 1986; Ettlie, et al., 1984).

The distinction between the administrative and technical innovations relates to a more general distinction between social structure and technology (Evan, 1986). Technical innovations are concerned with products, services, and production process technology. They directly relate to basic work activities of an organization and can concern either product or process (Damanpour and Evan, 1984; Knight, 1967). Administrative innovations, on the other hand, are concerned with organizational structure and administrative processes. They indirectly relate to the basic work activities of an organization, but more directly relate to its management (Damanpour and Evan, 1984; Kimberly and Evanisko, 1981; Knight, 1967).

Product innovations are new products or services introduced to meet an external user or market need, while process innovations are new elements introduced into an organization's production or service operations -- input materials, task specifications, work and information flow mechanisms, and equipment used to produce a product or render a service (Knight, 1967; Utterback and Abernathy, 1975). Organizations differ in their emphases on product and process innovations for competitive advantages (Ettlie, 1983; Hull, Hage, and Azumi, 1985).

While the majority of past research differentiates between incremental and radical and between product and process innovations, there is disagreement whether administrative and technical innovations should be treated separately. Leavitt (1965) argues that most innovations involve administrative and technical components whereas Van de Ven (1986) contends that making such a distinction often results in a fragmented classification of the innovation process. Recent research on innovation diffusion as a mutual adaptation process (Leonard-Barton, 1988) also lends support to this viewpoint. Mutual adaptation is conceived as an iterative process of removing barriers to the adoption by making appropriate adaptations to the technology (or innovation) and the organization in order to bring them into alignment. Traditionally innovation studies have used one of the two perspectives -- technology- or innovation-based or organization-based. The first perspective takes an approach in which innovation is tailored to fit the organization. The second perspective takes an approach in which organization is molded to fit the technology. However, there is evidence that innovations and organizations mutually adapt to each other (Leonard-Barton, 1988; Van de Ven, 1986; Walton, 1989). Thus, classification of innovations into technological and administrative innovations may be inappropriate, and this distinction is not made in this study.

Having briefly discussed innovation and its types, we describe the classical theory of innovation diffusion next.

2.2 Classical Diffusion Theory or Communications Perspective on Innovation Diffusion

According to classical diffusion theory, diffusion of an innovation is considered a process of communication whereby potential adopters become aware of the innovation and are influenced to adopt through communication with prior adopters (Rogers, 1983). The diffusion is primarily a result of the communication process, and the patterns of adoption across populations of adopters reflect patterns of communications flow (Brown, 1981).

Since much of the classical diffusion theory has been developed in the context of individuals making voluntary decisions to accept or reject an innovation based on its perceived benefits from independent use (Fichman, 1992), researchers examine the roles of individuals who are well linked to outside networks and organizations (Attewell, 1992). These individuals are usually more innovative than others and can be identified by their personal characteristics (such as education, cosmopolitanism, etc). They (often called opinion leaders and change agents) adopt an innovation early on and their actions influence other potential adopters (who are in contact with them via some communication channel). The diffusion process starts out slowly among these early adopters and "takes off" as growing community of adopters is established. It then slowly levels off as the population of potential adopters is exhausted. Cumulative adoption of an innovation follows an S-curve.

The classical diffusion theory portrays adoption proceeding through many distinct stages -- from knowledge of the innovation through persuasion, decision, implementation, and confirmation (Rogers, 1983). At different stages, adopters are believed to be predisposed towards different kinds of influence (for example, mass media versus interpersonal channels of communication). Innovation itself is characterized as possessing certain characteristics (for example, relative advantage, compatibility, complexity, trialability, observability) which determine the rate and pattern of its adoption.

Much of the classical diffusion theory is applicable to adoption of innovations by organizations (Van de Ven, 1991). However, many modifications and extensions are needed (Fichman, 1992) as (1) many classical variables do not clearly map to the organizational level of analysis (for example, adopter characteristics), (2) the organizational adoption of an innovation is not typically dichotomous but one stage in a process that unfolds over time, and (3) the organizational decision process, particularly in the absence of a dominant individual decision maker, often involves complex interactions among many stakeholders. Rogers (1983, Chapter 10) provides a summary of early research on organizational innovation. More recently, Fichman (1992) and Kwon and Zmud (1987) have developed a more comprehensive framework for studying organizational innovation adoption and diffusion.

Studies on the organizational diffusion of innovations show that diffusion process proceeds through many distinct phases. The majority of them describe it as a three stage process -- comprising of initiation, adoption, and implementation (Thompson, 1969; Pierce and Delbecq, 1977). Others (see Kwon and Zmud, 1987; Kimberly and Evanisko, 1981) argue that the three-stage model ignores any post-adoption or post-evaluation process. To account for post-adoption behavior, Kwon and Zmud (1987) incorporated four implementation success measures -- acceptance, usage, performance, and satisfaction in the three-stage model, which was further modified by Zmud and Apple (1988). The result is a six-stage implementation process model (see Figure 2-1), each of which corresponds to a particular stage in Lewin's change model. The definitions of these stages are in given in Table 2-1.

Many variables have been identified in past studies which influence different stages of this model. Kwon and Zmud (1987) classify these variables in five broad categories: individual factors (job tenure, cosmopolitanism, education, and role involvement), structural factors (specialization, centralization, formalization, and informal network), technological factors (compatibility, relative advantage, and complexity), task-related factors (task uncertainty, autonomy, responsibility, variety, identity, and feedback), and environmental factors (heterogeneity, uncertainty, competition, concentration/dispersion, and interorganizational dependence). Table 2-2 in Appendix A shows relationship (as observed in past studies) of many of these variables with various diffusion phases.

Having briefly discussed the classical theory of innovation diffusion, we review diffusion of IT innovations next.

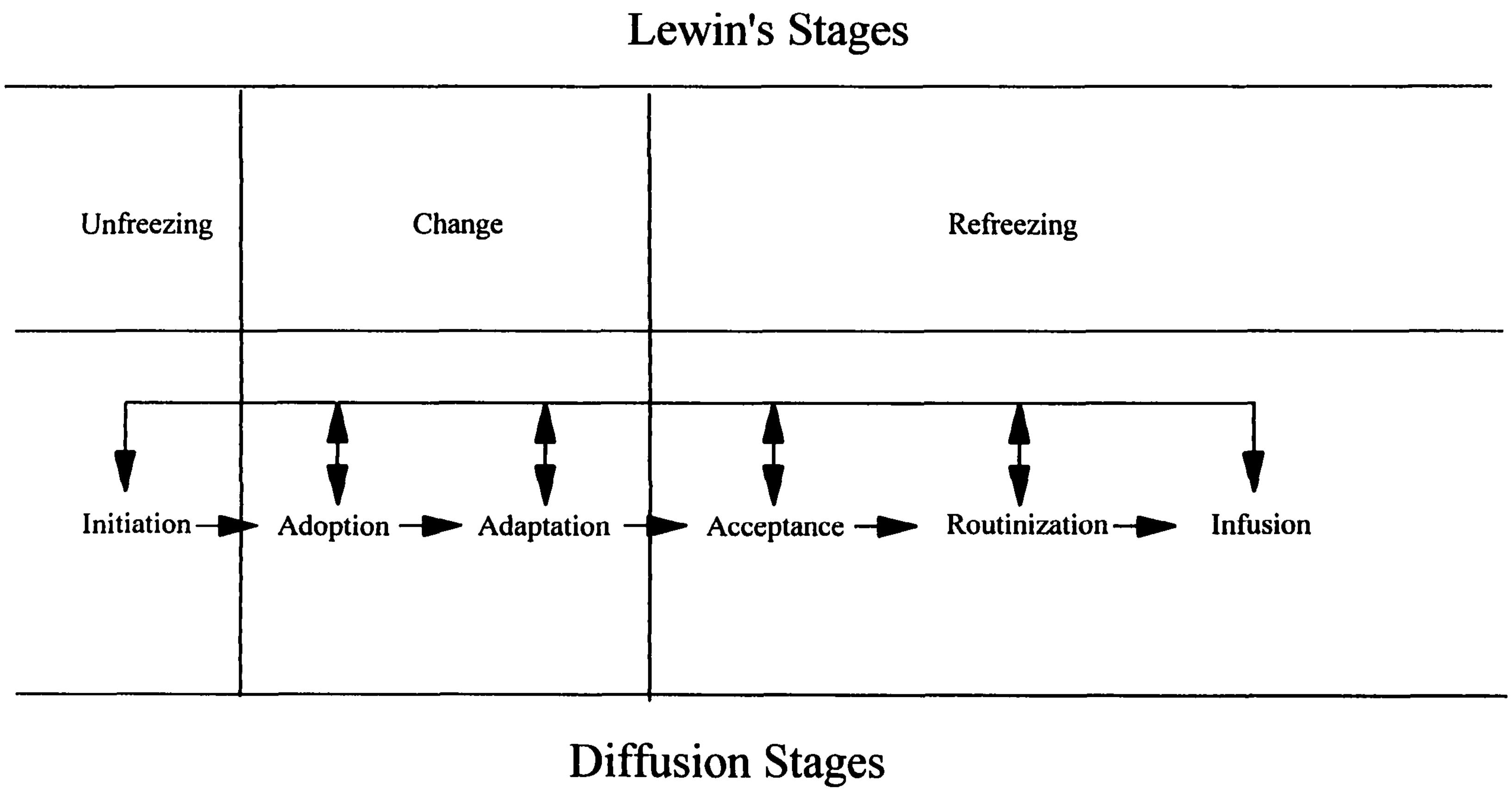

Figure 2-1. A Six-Stage Model of IS Implementation Process
(adopted from Kwon and Zmud [1987])

Table 2-1. Stages of Innovation Diffusion (Adapted from Cooper and Zmud (1990))

Initiation	Process:	Active and/or passive scanning of organizational problems/opportunities are undertaken. Pressure to change evolves from either organizational (pull), technological (push), or both.
	Product:	A match is found between innovation and its application in the organization.
Adoption	Process:	Rational and political negotiations ensue to get organizational backing for implementation of the innovation.
	Product:	A decision is reached to invest resources necessary to accommodate the implementation effort.
Adaptation	Process:	The innovation is "reinvented" (Rogers, 1983; Attewell, 1992), installed, and maintained. Organizational procedures are revised and developed. Organizational members are trained both in the new procedures and in the use of innovation.
	Product:	The innovation is available for use in organizational works.
Acceptance	Process:	Organizational members are induced to commit to innovation usage.
	Product:	The innovation is employed in the organizational work.
Routinization	Process:	Usage of the innovation is encouraged as a normal activity.
	Product:	The organization's governance systems are adjusted to account for the use of innovation; the innovation is no longer perceived as something out of the ordinary.
Infusion	Process:	Increased organizational effectiveness is obtained by using the innovation in a more comprehensive and integrated manner to support higher level aspects of organizational work.
	Product:	The innovation is used within the organization to its fullest potential.

2.3 Diffusion of IT Innovations

In the IT literature, diffusion of IT innovations has been primarily studied in the context of IT implementation (Kwon and Zmud, 1987) although innovation diffusion theory is the primary theoretical base for most of the implementation studies. For this reason, it is only fitting that IT innovation diffusion research be reviewed under the broader framework of IT implementation research.

2.3.1 Overview of IT Implementation Research

Despite the proliferation of information technology in organizations and work places, the implementation of information systems remains a significant issue (Lucas and Ginzberg, 1990). A number of implemented systems are underutilized, do not meet their potential, or are not used at all. IS implementation has been marred with widespread failures (Bostrom and Heinen, 1977; Kumar and Welke, 1984; Lucas, 1978; 1981; Zmud, 1983).

Much research has been done to develop a better understanding of both IT implementation problems and how they can be resolved. In 1981, after reviewing much of the implementation literature through 1980, Lucas identified three strands of research on IT implementation: theory, factor research, and process studies. Theory research deals with the propositions and ideas about implementation; factor research seeks various factors that are associated with implementation success; and process research deals with relationship among designers and users and how they approach the design problem.

Six years later, in a much cited work, Kwon and Zmud (1987) identified five streams of research -- factors, mutual understanding, process, political, and prescriptive --

on IT implementation. The factor research stream, like Lucas' factor research, focuses on the identification of factors responsible for implementation success and failure and is the largest of all the five research streams. A number of individual, organizational, and technological variables have been examined that potentially relate to IS implementation success. Factors found to have significant impact include (Fuerst and Cheny, 1982; Schultz, 1984; Sanders and Courtney, 1985; Ives and Olson, 1984; Churchman and Scahinblatt, 1965) top management support of the IS implementation effort, quality of IS design, degree of designer-user interaction during the implementation, and motivation of user. Based on these findings, Kwon and Zmud (1987) argue that successful IT implementation occurs when sufficient organizational resources (sufficient developer and user time, sufficient funding, sufficient technical skills, etc.) are channeled toward motivating and sustaining an implementation effort.

The quality of designer-user interaction is the focus of mutual understanding stream (Churchman and Schainblatt, 1965; Boland, 1978; Ginzberg, 1981b; Ives and Olson, 1984), which has been dominated by two topics -- the desirability of designer-user interaction and the cognitive functioning of designers and users. Findings in this stream suggest that the higher the quality of designer-user interactions, the more likely is IS implementation success.

The process stream of research views all implementation efforts as consisting of a sequence of generic stages, each of which must be successfully completed for implementation success. This stream focuses on social change activities rather than technical activities (Lewin, 1952; Kolb and Frohman, 1970; Schein, 1961). The findings from the process stream of research suggest that implementation success occurs (Ginzberg, 1979, 1981; DeSanctis and Courtney, 1983) when there is a strong commitment to change and implementation efforts, extensive project definition and planning takes place, and management of the process is guided by the organizational change theories.

The political research stream focuses on the diverse interests sought by different stakeholders. It recognizes that the diversity of interests affects IT implementation efforts and that successful implementation depends upon recognizing and managing this diversity (Kraemer, 1981; Markus, 1983; Pettigrew, 1972).

The prescriptive stream of research takes a broader perspective on IT implementation and focuses on risk factors and prescribes strategies for overcoming them. It examines the findings of the other research streams in order to identify universal implementation risk factors (Alter and Ginzberg, 1978; Keen, 1981; McFarlan, 1981), which typically include attributes of the individuals participating in an implementation effort, the organizational contexts within which implementation takes place, and the implementation project itself.

While the prescriptive research stream does draw on other research streams, Kwon and Zmud (1987) argue it does not provide an integrated perspective of IS implementation. In general, IT implementation research has been limited in both its perspective and its progress. Kwon and Zmud attribute the limited success in IT implementation research to the lack of a common directing and organizing framework among IT implementation researchers.

> "No one core set of constructs exists. Most studies focus on small pieces of the MIS implementation puzzle, without considering larger issues. And, most studies are couched in one, or at most two, of the research streams described above. As a result, it becomes very difficult to position individual studies within the fuller body of IS implementation research activities." (Kwon and Zmud, 1987, p. 231)

Towards that end, they draw on organizational change, innovation, and technological diffusion literatures to provide a consolidated model of IT implementation (see Figure 2-1). They define IT implementation as "organizational effort to diffuse an appropriate information technology within a user community" (Kwon and Zmud, 1987, p. 231). Their study shows that neither the organizational innovation research literature nor the IT implementation research literature has adopted a sufficiently broad perspective to explain introduction of new technologies into organizations. Most innovation research has examined individual, structural, and/or technological factors and has focused on adoption behaviors, while most IT implementation research has investigated individual factors and has focused on use (performance, satisfaction). They argue that an improved understanding of the process underlying technological innovation in organizations can be achieved if the perspectives and research agenda of these fields broaden to accommodate the contributions of each other. Below, we focus on the studies which use innovation diffusion theory to study IT implementation.

2.3.2 Overview of IT Diffusion Research

IT diffusion differs from classical diffusion assumptions due to IT's unique characteristics such as user interdependencies, knowledge barriers, etc (Fichman, 1992). When the adoption decision of individuals or organizations depends on the dynamics of community-wide levels of adoption because of network externalities (Katz and Shapiro, 1986; Markus, 1987), innovation is characterized as exhibiting user interdependencies. Similarly, when technologies cannot be adopted as a "black box" solution but rather impose a substantial knowledge burden on potential adopters, innovation is characterized to exhibit high knowledge burden. Fichman (1992) provides a framework (Figure 2-2) to map IT diffusion research based on the class of technology and the locus of adoption. He classifies technology in two classes: Type I and Type II. Type I technologies are characterized by a lack of user interdependencies and a lack of substantial knowledge burden on potential adopters. Typical examples of Type I technologies include single-user hardware (for example, microcomputers, laptops, portable terminals) and software (for example, word processing, spreadsheet). Type II technologies, on the other hand, are characterized by high knowledge barriers (for example, structured systems analysis, stand-alone CAD drawing system) or significant user interdependencies (for example, E-mail, voice mail) or both (for example, MRP, integrated CAD/CAM, integrated CASE). The locus of adoption can vary from individual to organization. Individual adoption studies examine the adoption of innovation among individual adopters. Typical dependent variables used in these studies include binary adoption of innovation, time of adoption, frequency of use, etc. Organizational adoption studies examine the adoption of innovation by organizations as a whole, and not by the individual adopters in the organizations. Important dependent variables in these studies include stages of diffusion and usage of innovation.

A thorough search of the IS literature resulted in 39 empirical studies (against Fichman's 18) of the diffusion of IT innovations. Table 2-3 in Appendix A summarizes

Class of Technology	Locus of Adoption	
	Individual	Organizational
Type I	6	4
Type II	1	28

Figure 2-2: Fichman's Framework (1992)

these studies along with their independent variables, dependent variables, the methodology used, major findings, the innovation studied, and the unit of analysis. The search included leading journals in the fields of information systems and management science. A study was included in the search if (1) the subject of the study was information technology,[1] (2) dependent variable(s) were some measure of adoption, and (3) the study looked at adoption by individuals in organizations or organizations as a whole. Table 2-4 shows mapping of these studies on to the Fichman's framework.

Six studies examined individual adoption of Type I technologies. The technologies included a text editor, a wordprocessing package, spreadsheet software, graphic software, personal computers, and an expert system. These technologies were used to facilitate self-contained tasks performed by individual users and imposed a relatively small knowledge burden. The subjects required only a few hours of training to attain a basic level of proficiency.

Findings of these studies broadly support classical diffusion theory. Davis (1989), Davis, Bargozzi, and Warshaw (1989), and Huff and Munro (1989) found that perceived innovation characteristics are related to adoption. Brancheau and Wetherbe (1990) found that communication channel types and sources play important roles in the adoption decision. Brancheau (1987), Brancheau and Wetherbe (1990), and Leonard-Barton and Deschamps (1988) found that early adopters can be distinguished from late adopters based on adopter characteristics. Brancheau (1987) and Brancheau and Wetherbe (1990)

[1]Information technology is defined here similar to Cooper and Zmud (1990) as any system, product, or process whose underlying technology base is composed of computer or communications software or hardware.

Table 2-4. Mapping of the 39 Empirical Studies on IT Diffusion on to the Fichman's Framework

		Locus of Adoption	
		Individual	Organization
Class of Technology	Type I	Brancheau (1987) Brancheau and Wetherbe (1990) Davis (1989) Davis, Bagozzi, and Warshaw (1989) Huff and Munro (1989) Leaonard-Barton and Deschamps (1988)	Bretschneider and Wittmer (1993) Grover and Teng (1993) Gatington and Robertson (1989) Raho, Belohav, and Fiedler (1987)

Table 2-4. Mapping of the 39 Empirical Studies on IT Diffusion on to the Fichman's Framework (continued)

		Locus of Adoption	
Class of Technology	Type 2	Leonard-Barton (1987)	Agarwal, et al. (1991) Ball, Dambolena, and Hennessey (1987) Cooper and Zmud (1990) Eveland, Rogers, and Klepper (1977) Finlay and Mitchell (1994) George, Nunamaker, and Valacich (1992) Gordon and Gordon (1992) Grover (1993) Grover and Goslar (1993) Gurbaxani (1990) Gurbaxani and Mendelson (1990) Kwon (1990) Mansfield (1993) Nilakanta and Scamell (1990) Orlikowski (1988, 1993) Premkumar, Ramamurthy, and Nilakanta (1994) Rai (1990, 1995) Rai and Howard (1993, 1994) Straub (1994) Vipond (1990) Wynekoop (1991) Zmud (1982, 1983, 1984)

confirmed that cumulative adoption over time follows an S-curve. Future research in this category should concentrate on integrating the various determinants of adoption into more sophisticated models, with correspondingly more sophisticated statistical techniques (Fichman, 1992).

Four studies examined adoption of Type I technologies at organizational level. The technologies included microcomputer technology, database management systems, laptops, and personal computers. Findings of these studies support the classical diffusion theory at organizational level, although to a lesser degree. Bretschneider and Wittmer (1993) found that organizational size, experience with computer technology, investment in computers, and availability of slack resources are significantly related to the microcomputer adoption in organizations. They also found that the sector in which an organization operates influences the adoption of microcomputer technology (public organizations have more microcomputers per employee than private organizations). Grover and Teng (1992) found that IS maturity, size of host organization, and industry in which the organization is in are significantly related to DBMS adoption. Gatington and Robertson (1989) found that adopter industry competitive effects (high concentration, low price intensity) and supplier industry factors (high vertical integration, high supplier incentives) predict adoption of laptop computers by sales organizations. Raho, Belohav, and Fiedler (1987) found support for McFarlan and McKenny's (1982, 1983a, 1983b) four phase (technology identification and investment, experimentation, learning, and adaptation, rationalization and management, and widespread technology transfer) model of organizational diffusion of personal computing and confirmed that educational commitments are related to the phase of diffusion.

Of the twenty-nine studies of Type II technologies, only one study (Leonard-Barton, 1987) examined the individual level adoption. This study examined the use of structured systems analysis (SSA) by individual users. Use of SSA involves significant knowledge burden as basic training for SSA typically extends over several days and users usually require months to reach a basic level of proficiency (Fichman, 1992). Thus, adopter's ability, not just willingness, may be a significant determinant of adoption. Leonard-Barton also found that level of industry experience was an important factor in discriminating adopters from non-adopters. Experienced users were more likely to adopt because they were more capable of grasping the benefits of the technology to create more maintainable code. In other words, they had a high absorptive capacity (see Cohen and Levinthal, 1990) with respect to this innovation. Client preferences, adopter attitudes, training in structured systems analysis, perceived accessibility to consulting, supervisor desires, and acquaintance with an advocate were other factors discriminating adopters from non-adopters.

Relative lack of research on individual adoption of Type II technologies is a cause of concern. While the organization as a whole makes the initial adoption decision for complex technologies, the actions of individual adopters may have a large impact on the implementation process (Fichman, 1992). Thus, research on the individual adoption of Type II technologies may help understand organizational adoption of these technologies better.

Twenty-eight of thirty-nine studies examined adoption of Type II technologies at organizational level. The technologies studied included expert systems (Agarwal, et al., 1991), data base management systems (Ball, Dambolena, and Heneessey, 1987; Gordon and Gordon, 1992), the BITNET computing network (Gurbaxani, 1990), software development process technologies (Nilakanta and Scamell, 1990; Zmud, 1982, 1983, 1984), computer-aided software engineering (Finlay and Mitchell, 1994; Orlikowski, 1988, 1993; Rai, 1990, 1995; Rai and Howard, 1993, 1994; Vipond, 1990, Wynekoop, 1991), "information technology" (Gurbaxani and Mendelson, 1990; Kwon and Zmud, 1990; Zmud, Boynton, and Jacobs, 1989), material requirements planning (Cooper and Zmud, 1990), GBF/DIME (Eveland, Rogers, and Klepper, 1977), electronic meeting systems (George, Nunamaker, and Valacich, 1992), customer-based information systems (Grover, 1993), telecommunications technologies (Grover and Goslar, 1993), electronic data interchange (Premkumar, Ramamurthy, and Nilakanta, 1994), email (Straub, 1994), and flexible manufacturing systems (Mansfield, 1993).

Mainframe database management systems ((Ball, Dambolena, and Heneessey, 1987) and expert systems (Agarwal, et al., 1991) are quite complex and are usually intended to support integrated applications with many interdependent users. Similarly, distributed database management systems are complex and involve integration of data and coordination of transaction activities across many locations (Gordon and Gordon, 1992). Software process technologies and CASE impose a large knowledge burden, while BITNET is subject to network externalities. "Information technology" when operationalized at the business unit level within large organizations is typically dominated by mainframe-based transactions processing and MIS style systems, and hence is user interdependent technology with a large knowledge burden. Material requirements planning and flexible manufacturing systems are quite complex, impose a large knowledge burden, and involve support and coordination of many applications and interdependent users. Electronic meeting systems, customer-based information systems, telecommunications technologies, electronic data interchange, and email are highly user interdependent technologies.

Findings of these studies show that few predictions of the classical diffusion theory hold. Two major predictions consistent with the classical diffusion theory were supported by these studies: an S-shaped cumulative adoption curve was confirmed by Gurbaxani for the BITNET computing network[1] and two innovation characteristics -- technology complexity and task-technology compatibility -- were found positively associated with adoption of MRP by Cooper and Zmud.

In general the results of these studies, however, show inconclusive support for the classical theory of innovation diffusion. For example, the role of information sources and communication channels in the adoption process found very weak support. Zmud found support for only four of over a hundred expected relationship between information channels and level of adoption (1983, Table 3). Elsewhere, Ball, Dambolena, and Hennessey could not confirm that internal information sources are more influential than external source in determining adoption (1987, p. 26). Nilakanta and Scamell found no more significant relationships between information sources/communication channels and

[1]Althouh Gurbaxani and Mendelson observed a more intricate pattern of adoption of IT at the national level, with cumulative adoption following an S-curve in the early days of computing followed by an exponential pattern in later years as the effects of decreasing price took over.

adoption than would be expected by pure chance (1990, Tables 5 and 6). Kwon found that only one of five "network behaviors" was a significant predictor of IT infusion (1990, p. 143).

On the organizational characteristics side, Zmud found only two of twelve predicted relationships between centralization and formalization and stage of adoption (1982, Table 3). Ball, Dambolena, and Hennessey found that only three of fourteen organizational characteristics were significantly correlated with adoption (1987, p. 23).

An overview of these studies in general shows that as one moves from individual level-Type I technology studies to organizational level-Type II studies in the Fichman's framework, the classical theory becomes less and less applicable. One interpretation of this finding is that classical diffusion variables by themselves may not be strong predictors of adoption and diffusion of type II technologies at organizational level (Fichman, 1992). Future research on IT diffusion at organizational level will need to consider other than classical or communications perspective, such as market and infrastructure, economic, and organizational learning perspectives, to account for these inconsistencies.

The methodologies used by these studies may be another cause for the inconclusive results (Fichman, 1992). An overwhelming majority (29 of 39) used mail survey as the preferred methodology (see Table 2-5). Out of 23 studies that used mail survey methodology to study innovation diffusion at organizational level, 20 used single informant survey and only 3 used multi-informant survey. This is not surprising knowing the difficulty in conducting a multi-informant survey. Only five studies used case study

Table 2-5. A Summary of Methodologies Used by the 39 Empirical Studies

Data Collection Method	Studies
Survey (individual)	Brancheau and Wetherbe (1990) Davis (1989) Davis, Bagozzi, and Warshaw (1989) Huff and Munro (1989) (personal interviews) Leonard-Barton (1987) Leonard-Barton and Deschamps (1988)
Survey (organization -- single informant)	Ball, Dambolena, and Hennessey (1987) Bretschneider and Wittmer (1993) Cooper and Zmud (1990) Eveland, Rogers, and Klepper (1977) Gatington and Robertson (1989) Grover (1993) Grover and Goslar (1993) Grover and Teng (1992) Mansfield (1993) Rai (1990, 1995) Rai and Howard (1993, 1994) Raho, Belohav, and Fiedler (1987) Straub (1994) Wynekoop (1991) Zmud (1982, 1983, 1984) Zmud, Boynton, and Jacobs (1989)

Table 2-5. A Summary of Methodologies Used by the 39 Empirical Studies (continued)

Data Collection Method	Studies
Survey (organization -- multiple informant)	Kwon (1990) Nilakanta and Scamell (1990) Premkumar, Ramamurthy, and Nilakanta (1994)
Case Study	Agarwal, et al. (1991) Finlay and Mitchell (1994) Gordon and Gordon (1992) George, Nunamaker, and Valacich (1992) Orlikowski (1993)
Ethnography	Orlikowski (1990)
Field Study	Brancheau (1987) Vipond (1990)
Secondary/archival data	Gurbaxani (1990) Gurbaxani and Mendelson (1990)

approach. Rich ethnographic methodology was used by one study (Orlikowski, 1990), while two employed field study (Brancheau, 1987; Vipond, 1990) and two used secondary/archival data (Gurbaxani, 1990; Gurbaxani and Mendelson, 1990). Organizational adoption of Type II technologies may be too varied, complex, and subtle to be usefully studied with cross-sectional survey methodology. Future research will do well by studying fewer organizations but in greater depth using such rich methodologies such as ethnography and replicated case studies (Fichman, 1992).

In this study we make an effort to address the shortcomings of the classical diffusion theory by discussing the necessity of complementing it with other perspectives. We proceed by first discussing the shortcomings of classical theory of diffusion, that is, communications perspective, and then discussing economic and market and infrastructure perspectives of innovation diffusion.

2.4 Shortcomings of Communications Perspective

Communication theory of organizational innovation primarily suffers from three major shortcomings. First, the theory operates under the assumption of an unchanging innovation (Brown, 1981). In reality, innovation is a continual process whereby the form and function of the innovation are modified throughout its life. Thus, the MS-DOS operating system software, while still called MS-DOS, has undergone almost yearly changes, since it was first introduced in 1980. Newer MS-DOSs are more efficient, have more features, and help in maximizing the utilization of the upper memory beyond the conventional 640K barrier. Second, the theory emphasizes the demand aspect of diffusion, assuming that everyone has an equal opportunity to adopt; the supply side of the innovation is almost ignored. In fact, institutions that supply and market innovations determine to a certain extent who adopts them and when. "The opportunity to adopt is egregiously and in many cases purposely unequal." (Brown, 1981, p. 7) In past, adopters have been given incentives in the form of subsidies (the diffusion of Internet in the beginning till it reached a critical mass is a good example in point), low-interest loan, hours of free telephone service (for example, a number of on-line services such as America Online, Prodigy, etc have been giving many hours of free time to users), etc. Thus research need to go beyond the individualistic perspective which stresses the innovativeness of potential adopters, and need to examine instead the institutional and market structures that channel new technologies to users (Robertson and Gatington, 1987). Third, this perspective studies the technological adoption decisions of individuals or organizations without taking into account community issues, assuming that individuals adopt innovations for their own independent use (Fichman, 1992). However, there is evidence that the technology can be subject to network externalities (Katz and Shapiro, 1986; Markus, 1987), which means that the value of use to any single adopter will depend on the size of network of other users. Community effects are likely to be crucial for software engineering process innovations as the benefits of adoption usually depend on the size of the current and future network of other adopters. For example, widespread adoption of a software engineering process innovation increases the likelihood of the availability of complementary software tools.

Beyond these Eveland and Tornatzky (1990) provide a different set of criticisms.

They argue that "Problems arise when the diffusion model is applied in situations where its basic assumptions are not met." This happens in virtually every case involving complex, advanced technology (that is, Type II technology). They contend that diffusion theory has primarily focused on adoption decisions by an individual, and upon a relatively rationalistic adoption decision. Yet for advanced production technologies, "Decisions are often many (and reversed), and technologies are often too big and complex to be grasped by a single person's cognitive power -- or usually, to be acquired or deployed within the discretionary authority of any single organizational participant" (p. 124). When adoption is not a single event, and when complex organizational processes rather than individual decision-making come into play, the classical decision model (e.g., Coleman et al., 1966) based on an individual's decision being primarily influenced via communication with external agents, seems less applicable (Attewell, 1992). Eveland and Tornatzky (1990) recommend a perspective that views diffusion and adoption as occurring within contexts that constrain and mold choices. They enumerate five elements of contexts: nature of the technology itself, user characteristics, the characteristics of deployers, boundaries between deployers and users, and characteristics of communication and transaction mechanisms.

To overcome, these shortcomings, researchers (see Eveland and Tornatzky, 1990; Brown, 1981; Kelly and Kranzberg, 1978; Attewell, 1992) have called for new perspectives better suited to understanding the diffusion of complex technologies. Below we first briefly review the economic and market and infrastructure perspectives of innovation diffusion. Then, we examine some new lines of inquiries which have been used recently by researchers to understand organizational diffusion of complex technological innovations.

2.5 Economic Perspective

From an economic perspective, diffusion is primarily viewed in terms of costs and benefits. The higher the cost, the slower the diffusion. On the other hand, the higher the perceived benefit from an innovation, the faster the adoption will occur (Mansfield, 1968). It takes into account both supply and demand side variables. The S-shape of the adoption over time is explained in terms of shifting balance of supply and demand, which is a function of the investment required to adopt a technology and the profitability of that technology (Freeman, 1982; von Hippel, 1988; Jowett, 1986; Mansfield, 1968, 1977). The steep "take-off" of the S-curve is viewed to signify a significant drop in the price of the innovation, causing an increase in demand.

The economic perspective pertaining to the diffusion of innovation is divided into two schools. The traditional school is more concerned with the invention than with the diffusion process. It embodies the assumption that the innovation is essentially the same throughout the diffusion process. The process of change in the innovation itself, on the other hand, has been the primary concern of the other school of economic history. From this perspective, innovation is seen as a continual rather than as a discrete process whereby the form and function of an innovation and the environment into which it is adopted are modified throughout the life of the innovation. In general, the market or economy is perceived to be in a long-run competitive equilibrium between the old and the new technology. The proportion of each technology represented at any particular time reflects the costs of each relative to the other, and the old technology is replaced gradually as the cost ratio (of the new to the old) decreases. These costs are both endogenous to the technology, as represented by its productivity, and exogenous, as represented by the price of required inputs or the relative factor costs (Brown, 1981).

Economic aspects of innovation diffusion have been described to account for the continual technological improvement and adaptation of the innovation to the market, which leads to adoption by an increasingly wider range of adopters. This continuity of innovation directly affects the temporal and spatial patterns of diffusion in two ways (Brown, 1981). First, on the supply side, the time at which a particular innovation is adapted or improved for a given use, market or set of potential adopters has a direct bearing on where and when the innovation will be (made) available, and hence adopted. Second, on the demand side, even after the innovation is made available, potential adopters will often delay their decision on the basis of expecting further improvements in the innovation. In this regard, the economic perspective complements the communications perspective -- the expectation of further improvements in the innovation is an alternative to the traditional explanation that lags in adoption reflect differences in innovativeness or resistance among individuals or firms (Brown, 1981).

Brown (1981) in a comprehensive review of the economic perspective has identified six factors that are relevant to the innovation diffusion. One such factor is the continuity of inventive activity. A second factor is the development of technical skills among users of the innovation which enable exploitation of its potential. The third factor is the development or routinization of skills so that the innovation can be made widely available to the potential users at a relatively low cost. The fourth is complementarities which relax or enable overcoming the constraints that develop in the course of applying the new technology. The fifth factor is improvements in the technology being replaced by the innovation. These improvements represent an entrepreneurial response to the competitive technology and retard its diffusion. The sixth factor identified in the context of the continuity of innovation is the institutional. Unlike the five factors listed above which are endogenous, institutional occurrences are exogenous in that they are outside the innovation's production process or the technology it is replacing, although either might be affected by these occurrences. Examples of institutional occurrences include political moves or technological changes which affect resource scarcity or abundance and relative factor prices, broad-scale processes such as urbanization which significantly alter market potentials either in favor of or against the innovation, and various sorts of arrangements that provide and channel production related or specialized information.

Economic historians argue that the slow initial rates of diffusion reflects the time needed to improve the innovation and adapt it to a variety of potential markets or uses, as well as delays and caution in adoption in expectation of such improvements. Similarly, they attribute the "take-off" or bandwagon effect to the development of technical skills among users, the routinization of skills in machine making, the development of complementarities and the completion of the bulk of ongoing inventive or adaptive activity with regard to the innovation.

Elsewhere, in a study of the adoption of software engineering process innovations, Fichman and Kemerer (1993) argue that economic aspects are responsible for the community effects of diffusion innovations, particularly for those innovations that are subject to increasing returns to adoption. Increasing returns to adoption means that the benefits of adopting an innovation will largely depend on the size (past, present, and future) of community of other adopters. While the communications perspective recognizes the effects of community adoption on the perception of potential adopters (e.g., by increasing social pressure to adopt), economic perspective takes the position that community adoption levels also affect the inherent value of a technological innovation that is subject to large increasing returns to adoption.

Fichman and Kemerer (1993) identify three factors -- learning by using, positive network externalities, and technological interrelatedness -- as the primary sources of increasing returns to adoption. Learning by using connotes that a technology's price-performance ratio improves rapidly as community of adopters (vendors and users) accumulate experience in developing and applying the technology, and is similar to Brown's development or routinization of skills. Positive network externalities indicate that the immediate benefits of use are a direct function of the number of current adopters. (An example is the Internet where the number of people available for email depends on the number of previous subscribers). Technological interrelatedness signifies that a large base of compatible products is needed to make the technology worthwhile as a whole.

This perspective views adoption much more dichotomously: if a technology achieves critical mass within some reasonable period of time, it will become dominant. Otherwise, the tide of expectations about the technology will turn among "swing adopters," those who will consider adoption only if they expect the technology to dominate, and adoption will abruptly plateau or even turn negative as adopters discontinue use. Four elements -- prior technology "drag", investment irreversibility, sponsorship, and expectations -- determine whether a technology subject to increasing returns to adoption will achieve a critical mass. (See Table 2-6 for definitions). When a prior technology has a large installed base, few adopters are willing to absorb the transition costs associated with joining an undeveloped network of adopters of new technology. Hence the existence of a prior technology's installed base represents a "drag" on the community's progress toward switching to the new technology. When adoption requires large, irreversible investments, this reluctance grows even stronger because a substantial risk must be taken if a satisfactory network is never developed for the new technology and adopters are stranded (Farrell and Saloner, 1987).

A new technology can overcome the head start of a prior technology in two ways: strong sponsorship and positive expectations. Sponsor can tilt the cost-benefit equation in favor of the new technology by actively subsidizing early adopters, by making credible commitments to develop the technology regardless of the initial adoption rate, and by setting standards that ensure that a single network will emerge around the new technology instead of islands of smaller, potentially incompatible networks. Expectations about a technology's chances for dominance are also a critical factor in this interpretation of economic perspective as expectations largely determine critical mass dynamics. Early in the development cycle, promising new technologies typically enjoy a "honeymoon" period during which some firms join an immature network expecting that widespread

Table 2-6. Economic Factors Affecting Technology Adoption (after Fichman and Kemerer, 1993)

Prior technology Drag	A prior technology provides significant benefits because of a large and mature installed area
Irreversibility of Investments	Adoption of the technology requires irreversible investments in areas such as products, training, and accumulated experience
Sponsorship	A single entity (person, organization, consortium) exists to define the technology, set standards, subsidize early adopters, and otherwise promote adoption of the new technology
Expectations	The technology benefits from an extended period of widespread expectations that it will be pervasively adopted in the future

adoption will occur later. If not enough firms hold these positive expectations to begin with, or if the honeymoon period is short, then critical mass may not be achieved. A strong scientific base and a good match between the technology's characteristics and industry needs to a large extent determine the length and robustness of a new technology's honeymoon period.

Fichman and Kemerer (19913) argue that the economic (or technology standards) approach to adoption of new technologies complements the communications approach in three key ways. First, it defines a special class of innovations -- those subject to increasing returns to adoption, to which software process technologies clearly belong. Second, it identifies several communitywide variables, which are not considered in the communications perspective, but have an impact on the adoption of such technologies. Third, it predicts different patterns of adoption for technologies subject to increasing returns to adoption.

2.6 Market and Infrastructure Theory

The market and infrastructure perspective of organizational innovation diffusion contends that the opportunity to adopt an innovation is unequal (Brown, 1981). According to Brown "... individual behavior does not represent free will so much as choices within a constraint set and that it is government and private institutions which establish and control the constraints." (p. 8). This perspective posits that a potential adopter will not have the option to adopt unless some government, entrepreneurial, or non-profit organization makes the innovation available at or near the location of the potential adopter through some means such as by establishing a diffusion agency. Accordingly, it focuses on the supply side of diffusion, that is, the process by which innovations and the conditions for adoption are made available to potential adopters -- individuals, households, and organizations. In general, knowing about innovations and having access to them are determined by the ways in which resources are made available or allocated to different adopters, both by propagators of innovations and by society at large. The potential adopter's ability to utilize these resources is also important. Thus, characteristics of adopters which is important in communications perspective is also important in market and infrastructure perspective.

This perspective conceptualizes diffusion as a process involving three activities (Brown, 1981): (1) establishment of diffusion agencies (or outlets) through which the innovation is distributed to the population at large; (2) establishment of innovation, which involves a strategy by each agency to induce adoption among the population in its service area; and (3) adoption of the innovation. Conceptually recognizing the supply side of diffusion shifts attention to the diffusion agency instead of the adopter. The locations of these agencies and the temporal sequencing of their establishment determine where and when the innovations will be available. These factors create differing levels of access to the innovation depending upon a potential adopter's economic, locational, social and demographic characteristics. The establishment of diffusion agencies and the operating procedures of each agency in general involves both the creation of infrastructure and its utilization. Thus, the characteristics of the relevant public and private infrastructures -- such as service, delivery, information, transportation, electricity or water systems -- also have an important influence upon the rate and spatial pattern of diffusion.

A diffusion agency can be established under three organizational structure -- centralized decision-making structure, decentralized decision-making structure without a coordinating propagator, and diffusion under decentralized decision-making structure with a coordinating propagator. The factors (enumerated below) important in each of these cases are more or less the same, although their roles differ across the continuum.

The diffusion agency operating under a centralized decision-making structure can be affected by capital availability, sales potential, logistics, and elasticity of agency profitability with regard to sales potential. The diffusion agency operating under decentralized decision-making structure without a coordinating propagator is influenced by characteristics of the local entrepreneur (sufficient capital to establish an agency, capable of seeing the potential of the innovation, be willing to take the required risks and expend the required effort and possess certain promotion and management skills) and congruence of the innovation with the ongoing activities of the entrepreneur. The factors affecting a diffusion agency under decentralized decision-making structure with a coordinating propagator are primarily the characteristics of the coordinating propagators and a combination of factors affecting the other two organizational structures.

Diffusion agency determines the pattern of diffusion at the more local market area level of aggregation. Four elements -- the development of infrastructure and organizational capabilities, pricing policy, promotional communications, and market selection and segmentation -- affect the outcome of the diffusion agency strategies. The first two of these elements primarily affect the objective attributes of the innovation, whereas the last two primarily affect its subjective attributes, that is, the beliefs of potential adopters about the objective attributes and/or the potential adopter's evaluation of them. Diffusion agency strategy and the exact form of each of the strategy elements are influenced by and reflects the conditions of the diffusion itself. Important conditions are -- the characteristics of innovation, the characteristics of the diffusion agency, the life cycle of stage of the innovation, and the spatial extent of diffusion.

Drawing upon the characterization of a diffusion within a market area as either infrastructure constrained or infrastructure independent, an abstract theoretical argument as to what kinds of diffusion patterns might be expected under different conditions of infrastructure development, pricing, promotional communications and market selection and segmentation can be made. While traditional models of diffusion primarily predict distance decay patterns outward from the urban center ("gravity model"), this theory predicts a uniform distribution of adoption. In the case of infrastructure-independent diffusion, the spatial extent of this is in general unlimited, but from the perspective of the individual diffusion agency it is bounded by the limit of the agency's service area. In the case of infrastructure-constrained diffusion, a uniform distribution of adoption is expected only within the area served by the infrastructure.

The communications and market and infrastructure perspectives of innovation diffusion are congruent to each other. The basis of this is that diffusion agency establishment under a decentralized decision-making structure actually represents adoption by a local entrepreneur, which renders it comparable to the firm's decision to adopt a technological innovation.

Based on above discussion, it can be concluded that there is a distinct supply side to the diffusion of technological innovations which affects both the spatial and temporal patterns of diffusion. The considerations pertaining to industry structure, market penetration, infrastructure and organizational development, pricing, promotional communications and market selection and segmentation, therefore, also are relevant in the diffusion of technological innovations. This perspective, however, by itself provides only a partial picture of the innovation diffusion phenomenon, because it considers only the supply side of the diffusion process. Nevertheless, it complements the communications perspective of the innovation diffusion which considers only the demand side of the innovation diffusion phenomenon.

So far, we have examined the three complementary perspectives of innovation diffusion: the economic history perspective dealing with the preconditions for diffusion; the market and infrastructure perspective, a supply side concern dealing with the way innovations are made available to potential adopters; and the communications perspective, a demand side concern dealing with adoption of the innovation. Below we argue that these three perspectives together provide still an incomplete view of the innovation diffusion phenomenon. We contend that learning aspects of the diffusion process must be considered to provide a fuller picture of the innovation diffusion process.

2.7 Learning Perspective

2.7.1 Evidence of Learning in the Diffusion Process in Past Studies

A review of past diffusion research shows that learning is implicitly assumed as an essential part of innovation diffusion process. For example, Rogers (1983) states:

> "There is obviously much in common between *social learning* and diffusion: both theories seek to explain how individuals change their overt behavior as a result of communication with another individual. Interpersonal networks are thus thought to be fundamental to behavior change, although neither theory claims that identical mimicking must occur. Both theories stress information exchange as essential to behavior change, and view such network links as the main explanation of how individuals alter their behavior." (italics added, p. 305)

Elsewhere, Hamblin, et al. (1979) point out:

> "diffusion models portray society as a *huge learning system* where individuals are continually behaving and making decisions through time but not independently of each other....Everyone makes his own decisions, not just on the basis of his own individual experiences, but to a large extent on the basis of the observed or talked about experiences of others." (italics added, p. 345)

In the IS literature, Argyris (1977) suggests that there are other and perhaps deeper reasons for the IT implementation failure than suggested in the IS literature. He argues that in order to understand the inner contradictions found from the studies of numerous IT implementations, information systems implementation must be viewed as part of a more general problem of organizational learning.

2.7.2 Attewell's Study of IS Innovations

More recently, Attewell (1992) in his study of business computing in organizations concludes that learning is an integral part of diffusion, especially for complex innovations within and across organizations. He bases his argument on the role of information and knowledge and that of knowledge transfer in the diffusion process.

2.7.2.1 Role of Information and Knowledge in Innovation Diffusion

According to Attewell (1992), the limitations of the communications theory of diffusion become obvious if one considers more closely the role of information and knowledge. The classical studies emphasize the role of the flow of information and ideas and the importance of communication between originators of the innovation and potential users in the diffusion process (Coleman, et al., 1966). A central premise is that non-adopters lag behind early adopters because the former have not yet learned of the existence of an innovation, or have not been influenced about its desirability by better-informed contacts. Thus, according to classical theory diffusion is limited by the timing and pattern of communication.

Unfortunately, classical studies fail to distinguish between two types of communication (or information) involved in the diffusion process: signaling versus know-how or technical knowledge. Differentiating between these two leads to very different perspective on technology diffusion. Signaling refers to communication about the existence and potential gains of a new innovation. Unless a potential adopter knows about an innovation and is informed persuasively about its benefits, the innovation is unlikely to be adopted. The classical diffusion studies assume that signaling information take different lengths of time getting to different potential adopters (according to their centrality to communications networks and links to prior adopters), resulting in the early, middle, and late S-curve adopters. Signaling is therefore viewed central to explaining the diffusion process.

However, one may question whether signaling information is a limiting factor in situations where information about the existence of new technologies and their benefits is widely broadcast by manufacturers' advertisements, by specialized business journals, and by trade associations (Burt 1987). Mansfield (1985) found that signaling about new technological innovations, especially in the US, can be very fast and widespread. Thus, signaling may not be a limiting factor that determines the pattern or timing of diffusion.

According to Attewell (1992), learning and/or communicating the technical knowledge required to use a complex innovation successfully places far greater demands on potential users and on supply-side organizations than does signaling. The amount and detail of information is far greater in the former case. If obtaining technical knowledge is slower and more problematic, it can be posited that it plays a more important role in the diffusion of complex technologies than does signaling. It should therefore move to center stage in any theory of innovation diffusion dealing with complex technology.

2.7.2.2 Role of Knowledge Transfer

In light of the above explication, one may conclude that the innovation diffusion studies which conceptualize the diffusion process in terms of knowledge transfer are erroneous (Attewell, 1992). These studies treat the movement of complex technical knowledge under a model of communication most appropriate for signaling. However, studies have shown that, although one can readily buy the machinery that embodies an innovation, the knowledge needed to use complex innovations is acquired much more slowly and with considerably more difficulty. There is evidence that manufacturers using new process technologies are able to realize productivity gains only several years after adopting a new technology, as they learn to use the technology to best effect (Dutton and Thomas, 1985) -- a process called "learning by doing" (Arrow, 1962). Others (Ray, 1969; Pavitt, 1985; von Hippel, 1988) have found that innovations need to be substantially modified inside user firms before they can be useful.

Absorbing a new complex technology not only requires modification and mastery of the technology (viewed in a narrow mechanical sense), but it also often requires (frequently unanticipated) modifications in organizational practices and procedures (that is, organizational learning, see Argyris and Schon, 1978) which are to be learned the hard way (Stasz, Bikson, and Shapiro, 1986; Johnson and Rice, 1987).

Rosenberg (1982) suggests that it is not only new process technologies that are learned in this fashion. The ultimate or end-users of complex products also face what Rosenberg calls "learning by using." He argues that, for complex technologies, the products are so multi-faceted, with interactions occurring between subsystems, that it is impossible for the designer to know in advance quite how they will perform when used. The result is "learning by using": the end-user spends several years developing an understanding of the strengths and weaknesses of the technology. The knowledge gained by these users becomes very important to manufacturers for designing new generations of equipment (Eveland and Tornatzky, 1990, p. 120).

Neither "learning by doing" nor "learning by using" is the result of knowledge transfer from the originator to the user of the innovation. Indeed there is the need for learning and skill information *in situ*. Rice and Rogers (1980) call this process "reinvention."

The implications of these studies are that know-how, far from being readily or easily transferred from the originator to the user of a technology, faces barriers and is relatively immobile (Boyle, 1986; Eveland and Tornatzky, 1990, p. 139). Knowledge often has to be discovered *de novo* within the user organization. Thus, Attewell (1992) argues that using an imagery of information transfer for technical knowledge obscures more than enlightens our understanding of innovation diffusion in organizations.

Theoretical considerations also suggest an alternative conception than transfer. The incentive to develop a new technology derives from the inventor's desire to monopolize the use of innovation. The faster it diffuses, the sooner one's advantage and ability to profit from it goes away. A major part of the economics of innovation examines whether licensing arrangements, patents, joint ventures, and other special institutional arrangements intended to make it profitable for innovators to share their innovations, actually do so (Kamien and Schwartz, 1982). The existence of these special inducements to share knowledge underlies the fact that the initial inclination of businesses is to hoard and hide know-how rather than transfer or diffuse it.

These critiques and studies imply that a different theory is needed to analyze the role of learning and technical knowledge in the diffusion of advanced production technologies, one that avoids the traditional notions built around signaling or transfer. Based on these arguments Attewell (1992) forwards a knowledge-barrier institutional-network approach to understand the diffusion process. This approach assumes that the immobility of technical knowledge is the main hurdle to adoption and necessitates organizational learning. A network of supply-side and user organization comes into existence to facilitate as opposed to mere transfer such learning. Mediating institutions also play an important role in lowering the knowledge barrier. This approach also suggests service as an alternative to adoption and argues that a transition occurs from service to self-service in due time.

Below we describe organizational learning in some detail.

2.8 Organizational Learning

Both academicians and practitioners recognize that organizational learning is an important strategic variable (Cosier, 1981; Kiechel, 1990; Normann, 1985). Some (see Cosier, 1981) even go as far as to say that organizational learning may be the only competitive advantage available to the company of the future.

2.8.1 What is Organizational Learning?

Consensus on the importance of organizational learning notwithstanding, there is disagreement on how organizations learn and what organizational learning is. Some say (see Daft and Huber, 1987) organizations may learn proper congruence over organizational characteristics such as strategy, structure, and technology. Others argue (see Duncan and Weiss, 1979) organizations may learn adaptation to their environment, choosing assessment and accommodation through approximate organizational design features. Still others contend (see Fiol and Lyles, 1985) that organizations may improve "actions through better knowledge and understanding". According to some researchers organizational learning can offer the opportunity for improved decision-unit effectiveness (Duncan, 1974), crisis prevention and coping with environmental change (Badeing, 1986; Nystrom and Starbuck, 1984), as well as premise reevaluation when previous beliefs are no longer sufficient for choosing appropriate organizational structures (Dery, 1986). According to others (see Huber, 1991) learning does not always increase the organization's effectiveness, or even potential effectiveness. In general, however, definitions of organizational learning underscore (1) interaction of organization with environment, (2) changes in organizational modeling of its environment, and (3) organizational action (McKee, 1992).

For the purpose of this research, organizational learning is defined as the detection and correction of error (Argyris and Schon, 1977). When the error detected and corrected permits the organization to carry on its present policies or achieve its present objectives. then that error-detection-and-correction process is *single-loop* learning. When error is detected and corrected in ways that involve the modification of an organization's underlying norms, policies, and objectives, then *double-loop* learning occurs. Senge (1990) calls these learning types adaptive and generative learning respectively.

Organizational learning occurs when individuals, acting from their images and maps, detect a match or mismatch of outcome to expectation which confirms or disconfirms organizational theory-in-use. The norms, strategies, and assumptions embedded in the company's practices constitute its theory of action. Organization's theory-in-use is what norms, strategies, and assumptions the organization practices rather than organizational espoused theory or theory of action which is usually well documented. Organizational theory-in-use can be inferred from the observation of organizational behavior -- that is, organizational decisions and actions carried out by the individuals in the name of the organization.

An organization learns through learning of individuals who are members of the organization. However, individual learning is only a necessary but insufficient condition for organizational learning. Duncan and Weiss (1979) stress that organizational learning "is more than the simple aggregate of individual learning ... [it] must involve the learning done by a given individual that can be shared, evaluated, and integrated with that done by others." In order to organizational learning to occur, learning agents' discoveries, inventions, and evaluations must be embedded in organizational memory; they must be encoded in the individual images and the shared maps of organizational theory-in-use from which individual members will subsequently act. If this encoding does not occur, individuals will have learned but the organization will not have done so.

Jelinek (1979) states that "a means of capturing or impounding ... insights is the first requirement for organizational learning." Others agree that successful organizational learning involves the acquisition of routines and procedures (Levitt and March, 1988), and conversely, the abandonment of routines and procedures (Dery, 1982). It also involves sharing assumptions, developing knowledge of action-outcome relationships, and institutionalizing experience (Shrivastava, 1983). Organizational learning may aid the firm through the refinement of knowledge (Duncan and Weiss, 1979), the acquisition of knowledge (Jelinek, 1979), as well as through the abandonment of knowledge (Nystrom and Starbuck, 1984). Prescriptions for organizational learning also involve, as noted above, the construction or acquisition of an institutional memory or organizational memory.

Constructs related to organizational learning, in general, may be classified in four categories (Huber, 1991): knowledge acquisition, information distribution, information interpretation, and organizational memory.

2.8.2 Knowledge Acquisition

Knowledge acquisition is the process by which knowledge is obtained. Organizations involve in many formal and informal activities to acquire knowledge or information. These activities can be broadly classified in five categories: congenital learning, experiential learning, vicarious learning, grafting, and searching.

An organization's congenital knowledge is a combination of the knowledge inherited at its conception and the additional knowledge acquired prior to its birth (for example, when an organization is "incorporated" or is formally granted a mission and resources by its parent organization). What an organization knows at its birth may determine what it searches for, what it experiences, and how it interprets what it encounters (Huber, 1991).

After their birth, organizations acquire some of their knowledge through direct experience called experiential learning. Sometimes this learning is a result of intentional, systematic efforts. Much more frequently it is acquired unintentionally or unsystematically. Experiential learning may take place through organizational experiments, organizational self-appraisal, experience-based learning curves, etc. In general, it is facilitated by the availability and analysis of feedback in formal experiments and in formal post hoc analyses of experiments. Approaches to facilitate experiential learning may include using increased accuracy of feedback about cause-effect relationships between organizational actions and outcomes and ensuring collection and analysis of such feedback (Wildavsky; Lawler, 1977; Warner, 1984; Landau, 1973, Huber, Ullman, and Leifer, 1979). Organizational self-appraisal is another form of experiential learning which involves a number of overlapping approaches that focus on member interaction and participation as critical to learning, and improving the organizational members' mental health and relationship as important goals of learning. Action research, a relatively data intensive approach to organizational self-appraisal, includes gathering information about problems, concerns, and needed changes from organizational members, organizing this information, sharing it with members, and involving the members in choosing, planning, and implementing actions to correct problems identified (Lewin, 1946; McNamara and weeks, 1982; Argyris, 1983; Trist, 1983; Peters and Robinson, 1984). While organizational experiments and organizational self-appraisal are generally directed toward enhancing adaptation, maintaining organizational experiments is generally directed toward enhancing adaptability. Adaptability is the capacity to expand niches or to find new niches (Boulding, 1978). Hedberg, Nystorm, and Starbuck (1977) argue that organizations should operate themselves as "experimenting" or "self-designing" organizations for survival in fast changing and unpredictable environments. Such organizations learn about a variety of design features and remain flexible, and thus would be less resistant to adopting unfamiliar features or engaging unfamiliar environments. Lastly, there is evidence that organization's experience enhance its performance. Brittain (1989) found that experience predicts organizational survival. Others (Dutton, Thomas, and Butler, 1984; Mody, 1989; Muth, 1986; Yelle, 1979) have found that as manufacturing organizations gain experience in producing a new product, their production cost and production time per unit decrease.

Vicarious learning involves learning through the experiences of other organizations rather than through first-hand experience. This learning may take place through consultants, professional meetings, trade shows, publications, vendors and suppliers, and in less competitive environments, networks of professionals. Earlier it was believed that diffusion of technologies and administrative practices takes place through vicarious learning (Dutton and Freedman, 1985; Levitt and March, 1988). However, Mahajan, Sharma, and Bettis (1988) provide evidence that suggests that vicarious learning may be a more limited way of diffusing innovations than previously suggested.

Organizations frequently increase their store of knowledge by acquiring and grafting on new members who possess knowledge not previously available within the organization. For acquiring complex forms of information or knowledge, grafting is often faster than acquisition through experience and more complete than acquisition through imitation or vicarious learning. However, searching is the process most consciously pursued by managers on a day-to-day basis to acquire information or knowledge. Organizational information acquisition through search can be viewed as occurring in three forms: (1) scanning, (2) focused search, and (3) performance monitoring. Scanning refers to the relatively wide-ranging sensing of the organization's external environment. Focused search occurs when organizational members or units actively search in a narrow segment of the organization's internal or external environment, often in response to actual or suspected problems or opportunities. Performance monitoring is used for both focused and wide-ranging sensing of the organization's effectiveness in fulfilling its own pre-established goals or the requirements of stakeholders. Organizations routinely assess how well they are meeting both their own standards, such as inventory levels, and the expectations of external constituencies and stakeholders. Noticing is the unintended acquisition of information about the organization's external environment, internal conditions, or performance.

2.8.3 Information Distribution

Information distribution is the process by which information from different sources is shared and thereby adds to new information or understanding. It is determinant of both the occurrence and breadth of organizational learning. With regard to occurrence of organizational learning, organizational components develop new information by piecing together items of information that they obtain from other organizational units, for example, when a shipping department learns that a shortage problem exists by comparing information from the warehouse with information from sales department. With respect to the idea that information distribution leads more broadly to organizational learning, it is worthwhile to consider the fact that organizations do not know what they know. Except for their systems that routinely index and store hard information, organizations tend to have only weak systems for finding where a certain item of information known to the organization is. But when information is widely distributed in an organization, so that more and more varied sources for it exist, retrieval efforts are more likely to succeed and individuals and units are more likely to be able to learn.

Organizational units with potentially synergistic information are often not aware of where such information could serve, and so do not route it to these destinations. Also, units which might be able to use information synergistically often do not know of its existence or whereabouts. One organizational process that facilitates the coupling of those who need nonroutine information and those who have it is internal employee transfer. Combining information from different units leads not only to new information but also new understanding.

2.8.4 Information Interpretation

Information interpretation is the process by which distributed information is given one or more commonly understood interpretations. Daft and Weick (1984) define interpretation as "the process through which information is given meaning" (p. 294) and also as "the process of translating events and developing shared understandings and conceptual schemes" (p. 286). It seems likely that the extent of shared interpretation of new information is affected by (1) the uniformity of prior cognitive maps possessed by the organizational units, (2) the uniformity of the framing of the information as it is communicated, (3) richness of the media used to convey the information, (4) the information load on the interpreting units, and (5) the amount of unlearning that might be necessary before a new interpretation could be generated (Huber, 1991). Other variables have also been found determinants of shared interpretations (Bartunek, 1984; Milliken, 1990), but these five have been singled out in the literature as especially relevant (Huber, 1991).

A person's cognitive map (or belief structure or mental representation of frame of reference) shapes his or her interpretation of information. These cognitive maps vary across organizational units having different responsibilities (Dearborn and Simon, 1958; Ireland, Hitt, Bettis, and DePorras, 1987; Kennedy, 1983, Walker, 1985; Zajonc and Wolfe, 1966). Similarly, it is well established that how information is framed or labeled affects its interpretation (Dutton and Jackson, 1987; Tversky and Kahneman, 1985). If information is not uniformly framed when distributed to different units, uniform interpretations are less likely to occur.

Media richness is a determinant of the extent to which information is given common meaning by the sender and receiver of a message. It is defined as the communication "medium's capacity to change mental representations within a specific time interval." (Daft and Lengel, 1984; Daft and Huber, 1987, p. 14) It has two underlying dimensions -- the variety of cues that the medium can convey and the rapidity of feedback that the medium can provide. Research supports the notion that managers who consider media richness when choosing a communication medium are more effective (Daft, Lengel, and Trevino, 1987), and thus provides some support for the idea that media richness affects the development of common understanding.

Information load affects the shared interpretation in the sense that interpretation within or across organizational units is less effective if the information to be interpreted exceeds the unit's capacity to process the information adequately (Meier, 1963; Driver and Streufert, 1969; Miller, 1978).

Unlearning is "a process through which learners discard knowledge." (Hedberg, 1981, p. 18) Unlearning opens the way for new learning to take place. An extreme form of intentional unlearning by organizations is the discharge of employees, especially mangers who are unable to move from outdated ways of doing things (Tunstall, 1983).

2.8.5 Organizational Memory

Organizational memory is the means by which knowledge is stored for future use.

To demonstrate or use learning, knowledge which has been learned must be stored in memory and then brought forth from memory. Variables likely to influence the ongoing effectiveness of organizational memory include (1) membership attrition, (2) information distribution and organizational interpretation of information, (3) the norms and methods for storing information, and (4) the methods for locating and retrieving stored information. Organizations store a great deal of knowledge about how to do things in the form of standard operating procedures, routines, and scripts (Feldman, 1989; Gioia and Poole, 1984; Nelson and Winter, 1982, pp. 99-107). Mangers and others routinely acquire and mentally store "soft" information as well. As a result of specialization, differentiation, and departmentalization, organizations frequently do not know what they know. The potential for reducing this problem by including computers as part of the organizational memory is considerable (Huber, 1991).

Organizational memory affects information acquisition, information distribution, and information interpretation processes. For example, information acquisition depends in many instances on attention, which is directed by previous learning retained in memory. Information distribution is affected by organizational decisions using criteria which are applied using information contained in memory. Information interpretation is greatly affected by cognitive maps of frames of reference, which are undefinable except in terms of a memory.

The substance of the memory generally includes the interpretations of the organizational in relation to the external environment. For example, Dery (1986) suggests that "if organizations are learning entities then these entities must have an epistemology ('mental maps,' 'perceptual filters') mediating between them and the welter of experience surrounding them." In understanding the external environment, then, choices are made about what information to consider and how to interpret it. The organization's memory reflects the experience acquired during this process. Unfortunately, as Levitt and March (1988) tell us "a good deal of experience goes unrecorded because the costs are too great." Consequently, the end result often is that "knowledge disappears from the organization's active memory (Neustadt and May, 1986).

Table 2-7 in Appendix A shows different organizational learning constructs and the variables under these constructs.

2.9 Necessity to Integrate Different Perspectives of Organizational Innovation Diffusion

As is evident from the prior discussion, each of communications, economic, market and infrastructure, and organizational learning perspectives provides unique insights into the innovation diffusion process. Unfortunately, each of these perspectives has proceeded rather independently of the others with little, if any, cross-referencing[1]. However, in considering them together, it is clear that the four perspectives are in fact complimentary and provide a comprehensive view of the innovation diffusion process. A good illustration of this point is alternative explanations given for the flatness of S-curve's left tail before "take-off" or bandwagon effect. The communications perspective

[1]To date only Fichman and Kemerer (1993) have used an elementary framework for combining the communications and economic perspectives of innovation diffusion. They applied this framework to successfully explain the diffusion of structured design and analysis methodologies, production fourth-generation languages, and relational database management systems.

attributes this to adopter's innovativeness characteristics or resistance to adoption. Economic historians argue that the slow initial rates of diffusion reflect the time needed to improve the innovation and adapt it to a variety of potential markets or uses, as well as expectation of such improvements. The market and infrastructure perspective attributes this to propagator and diffusion agency strategies. The organizational learning perspective attributes it to "knowledge barrier" for using the innovation.

A similar set of explanation is given for the "take-off" and differences in the rates of diffusion of different innovations. The communications perspective attributes the "take-off" to the lowering of adopter resistance to adoption to social interaction and other communications, and the variance in diffusion rates to different resistance levels for different innovation. Economic perspective attributes these to the development of technical skills among users, the routinization of skills or "learning by doing," and the development of complementarities. The market and infrastructure perspective attributes these same occurrences to a broad range of propagator and diffusion agency actions. The organizational learning perspective attributes these to lowering of knowledge barrier in using the innovation due to a variety of knowledge acquisition, information distribution, information interpretation, and organizational memory factors.

The four perspectives are not independent of one another, but rather interrelated (Figure 2-3). (Only direct effects are shown here. Solid-lined boxes show perspectives examined in this study.) They mutually affect the factors and processes by which a particular perspective affects the diffusion process. The overall locus of diffusion in organizations (and in population at large) is determined by the processes and factors

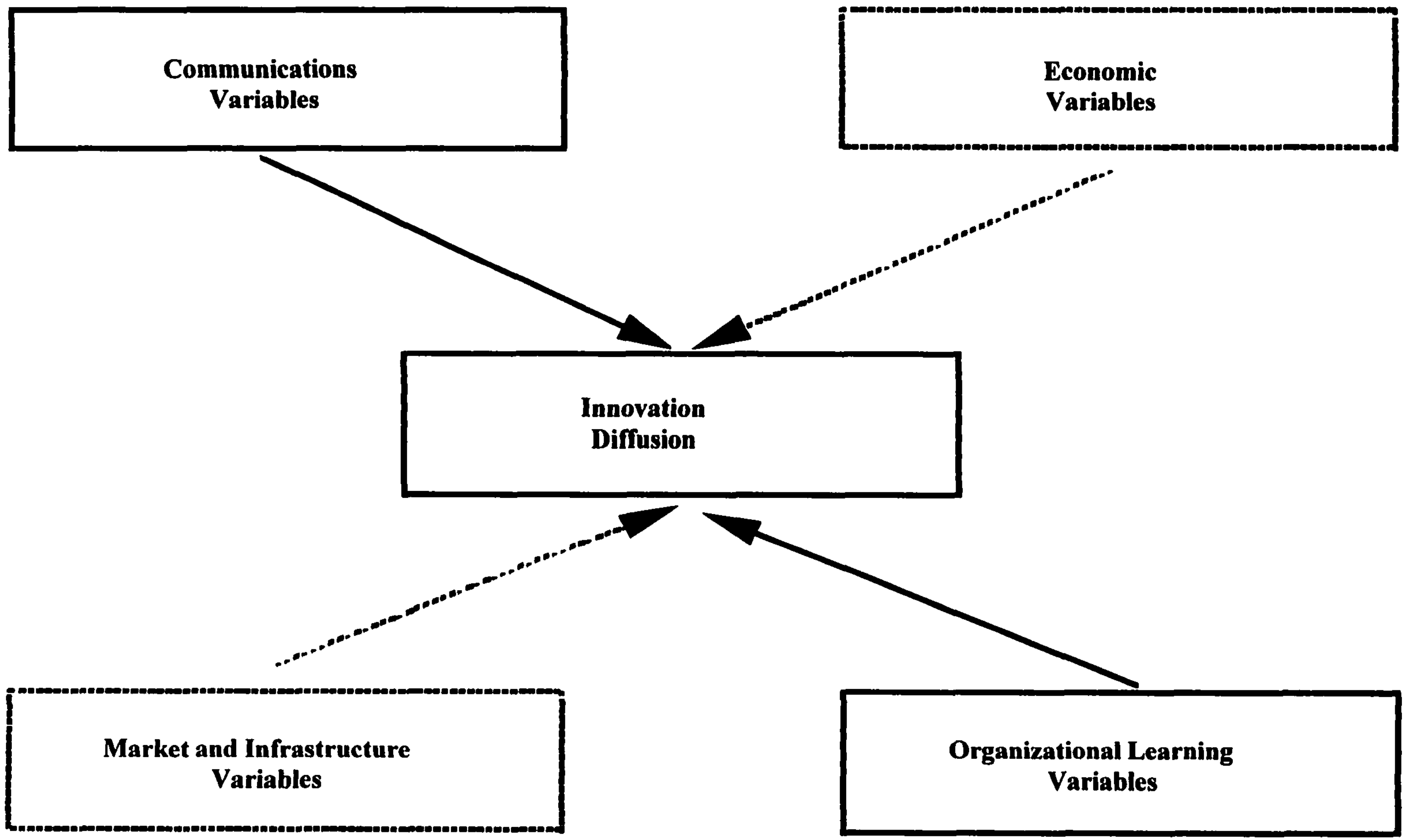

Figure 2-3: A Consolidated View of Organizational Innovation Diffusion

involved in all the perspectives, and not in isolation. It is not surprising to see that some of the variables play important roles in more than one perspectives.

It is also evident that all four perspectives do not play equal roles at the different stages of the diffusion process. In the initial stage when an invention is transformed into an innovation, economic perspective plays more central role than others. Economic variables largely determine whether an innovation will be continually improved and adapted to the market. Brown (1981) appropriately terms this stage as the preconditions for diffusion. At a later point in time, market and infrastructure variables which make innovation available to population at large play the dominant role as diffusion agency establishment and diffusion agency strategy establish to a large extent where and when an innovation will be available. During the latter part of the diffusion process, when the innovation is being adapted, accepted, routinized, and infused in the adopting organization, organizational learning variables become dominant. The communications perspective variables play more or less some role in all the stages of the diffusion process. However, it will be erroneous to conclude that only the variables from one perspective influence the course of diffusion at a particular stage. In fact, the variables from different perspectives together affect any diffusion stage. Thus it is highly desirable that future studies should examine organizational diffusion of complex technologies by integrating these perspectives to gain a holistic understanding of the innovation diffusion phenomenon.

This study is a step forward in that direction as it complements the communications perspective (or classical innovation diffusion theory) with organizational learning perspective to study diffusion of innovations in organizations.

CHAPTER III
RESEARCH MODEL FOR CASE DIFFUSION IN ORGANIZATIONS

This chapter builds on the theoretical foundation developed in the second chapter. It describes the research model used in this study, and discusses the innovation diffusion phases examined, namely, adoption and infusion, and the rationale for studying these phases. It also describes the innovation examined, that is, CASE technology, and the variables studied, and discusses the hypotheses developed for empirical testing.

3.1 Research Model

Figure 3.1 shows the research model used in this study. It draws on both communications perspective and organizational learning perspectives, and examines the effect of various variables from these perspectives on IT diffusion.

The variables examined from communications perspectives can be classified in two categories: characteristics of IS personnel and characteristics of technology. A review of 28 studies of Type II technologies at organizational level (see Table 2-3, Appendix A) shows that characteristics of the IS personnel is the least researched area. It can be surmised that since the objectives of these studies have been to study the innovation diffusion phenomenon at organizational level, the individual level variables were ignored. However, it is worth noting that most of the systems development work is done by groups of *individuals*. Since the characteristics of individuals to a large extent determine the characteristics of a group, characteristics of IS personnel are very likely to have some

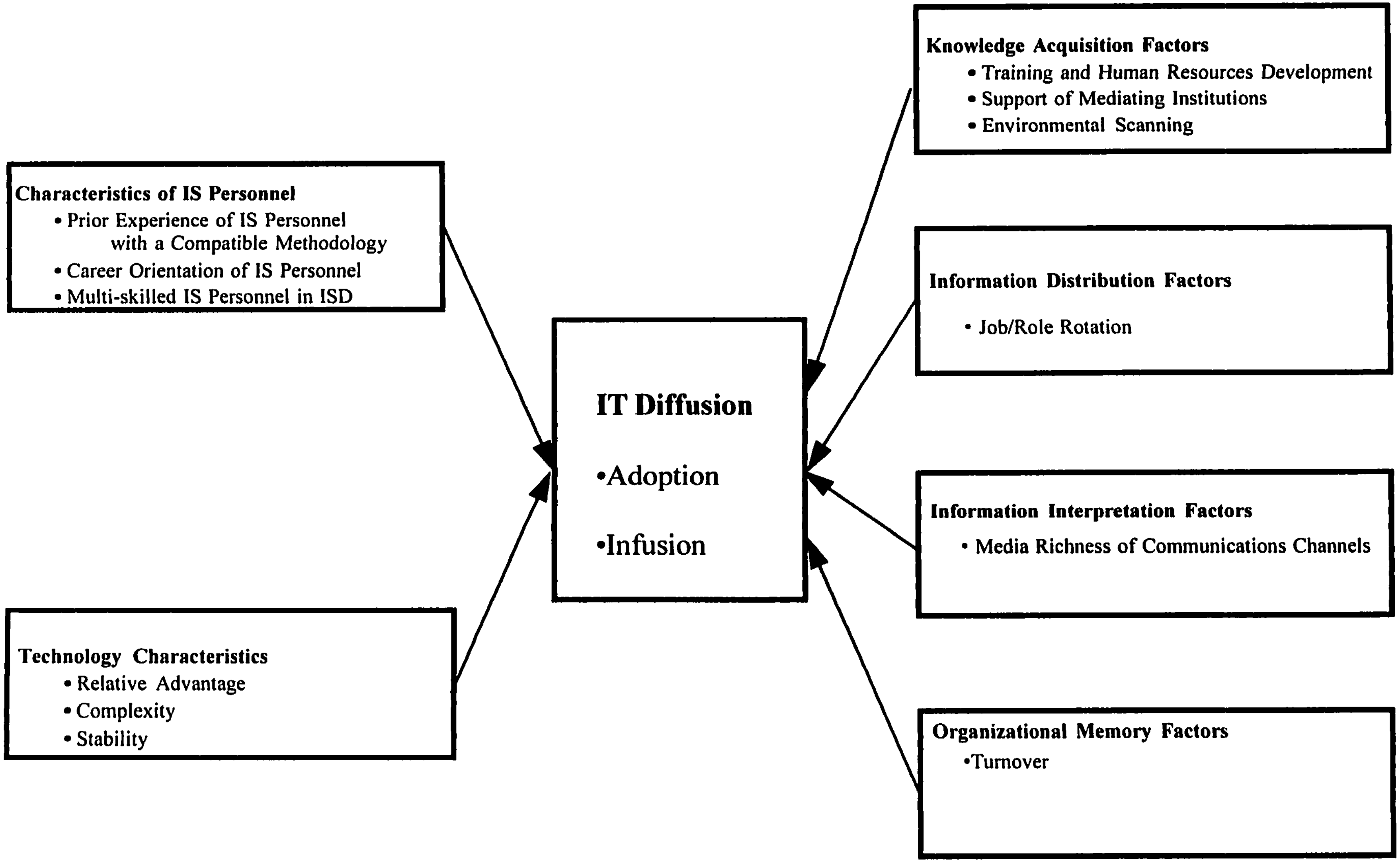

Figure 3-1. Research Model for IT Diffusion in Organizations

bearing on the diffusion process. Fichman (1992) also recognizes the importance of actions of individual adopters on the overall organizational diffusion process. Furthermore, literature in organizational learning shows that individuals are the learning agents of organizations. "... organizations learn only through the experience and action of individuals." (Argyris and Schon, 1978, p. 9) Thus, it seems important that individual level variables be paid more attention to. Therefore, three individual level variables -- prior experience of IS personnel, career orientation of IS personnel, and IS personnel's skill are included in the model.

Elsewhere Cooper and Zmud (1990) state that the lack of attention to IT technological characteristics is a serious deficiency in most IT implementation research. Keeping this in mind, technological characteristics of the IT innovation are also included in the research model. Kwon and Zmud (1987) identify three technological characteristics that may affect diffusion process -- compatibility, complexity, and relative advantage. In addition, in a recent study (Finlay and Mitchell, 1994) stability was also found to be an important technological characteristic in the implementation of CASE. Our model includes relative advantage, complexity, and stability.

As discussed in Chapter II, organizational diffusion of an innovation is also affected by organizational learning factors -- knowledge acquisition, information distribution, information interpretation, and organizational memory factors. Our model includes variables from all these factors. The variables examined under knowledge acquisition factor are training and human resources development of IS personnel, support of mediating institutions, and environmental scanning. The variable examined from the remaining three learning factors are job/role rotation of IS personnel, media richness of communications channel, and turnover of IS personnel.

Only direct effects of all these variables are examined in this study. Although our model categorizes these variables under communications and organizational learning perspectives, some variables, such as prior experience of IS personnel and career orientation of IS personnel, are likely to play roles in both these perspectives. This suggests the further need for integrating different perspectives in studying organizational diffusion of innovations.

3.2 Innovation Diffusion Stages Examined

Two diffusion stages, adoption and infusion, are examined in this study. *Adoption* is that stage of diffusion wherein a decision is made to invest resources necessary to accommodate the implementation of the innovation, and rational and political negotiations are made to get organizational backing for its implementation (Cooper and Zmud, 1990). *Infusion* is that stage of diffusion wherein the innovation is used to its fullest potential, and increased organizational effectiveness is obtained by using the innovation in a more comprehensive and integrated manner to support higher level aspects of organizational work (Cooper and Zmud, 1990).

Past research shows that variables may impact diffusion stages differently (Kwon and Zmud, 1987). Laudon (1985) has shown that factors associated with rational explanations of IT implementations success are more significant for earlier than later stages. In that vein Cooper and Zmud (1990) have examined two widely separated diffusion stages (adoption and infusion) in the context of MRP implementation. Their results lend support to Laudon's findings. We focus on adoption and infusion of CASE for two reasons. First, this will add to already accumulated knowledge about factors affecting adoption and infusion phases, but about a different technology. Over a period of time, such a rich repository of knowledge should allow researchers to compare the roles of different variables in the diffusion of different technologies. Second, if variables impact different phases differentially, their effects are likely to be more pronounced when these phases are further apart. The selection of the adoption and infusion phases should enable us to discern such differential effects.

At this point, it may be important to assess the appropriateness of the use of sequential stage model in studying technological diffusion in organizations. Past research shows (Ettlie, 1980; White, 1970) that sequential stage model may not portray the actual process of diffusion in organizations. However, recent research (Pelz, 1983) demonstrates that such models may be appropriate for technologies that are borrowed or adapted. In addition, Cooper and Zmud (1990) suggest that if the stages can be thought of as activities, some of which may occur in parallel, such a model can be used to portray a variety of IT applications and IT implementation processes in most organizations. In that vein Cooper and Zmud (1990), Rai (1995), Rai and Howard (1993), and Wynekoop (1991) have used stage model to study diffusion of both borrowed and custom-made IT in organizations. In this research, the technology studied is computer-aided software engineering (CASE) technology (discussed in detail in the next section), which may be either adapted or custom-made. Based on past research, we expect the stage model to be able to portray the diffusion process involved well in either case.

3.3 Computer-Aided Software Engineering

CASE aims to improve different activities of software engineering -- definition, design, production, and maintenance -- through the use and integration of automated software tools (Tate, Verner, and Jeffery, 1992). According to Yourdon (1986), "Just as CAD/CAM has helped revolutionalize various engineering disciplines over the last 25 years, so CASE technology will help revolutionalize the software industry." Others (see Tate, Verner, and Jeffery, 1992) have expressed similar views.

3.3.1 Definition

In the IS literature, CASE has been defined very broadly as "the automation of anything a human does to software" (Stamps, 1987) to more specifically as "tools that should enable integrated computer support for some or all of the activities in software engineering." (Spurr, 1989) The 1992 International Workshop on Computer-Aided Software Engineering (IWCASE) defines CASE as "... tools and methods to support an engineering approach to software development at all stages of the process." (Forte and Norman, 1992) The "engineering approach" signifies "a well-defined, coordinated, and repeatable activity with widely accepted representations, design rules, and standards of quality." (Forte and Norman, 1992) According to this definition, tools that support such an engineering approach are CASE tools regardless of the specific phase, task, or notation. In general, CASE consists of a portfolio of tools that automate any portion of the system development life cycle process, from graphic tools that speed the creation of data flow diagrams to artificial intelligence-based products that automatically generate procedural code from logical models (Howard, 1990).

3.3.2 Types of CASE Tools

A wide variety of CASE tools exist, each of which provides support for different phases of software development life cycle -- planning, design, analysis, construction, testing, and maintenance: front- and back-end CASE tools; forward and backward engineering CASE tools; integrated or full life-cycle CASE tools; methodology dependent and methodology-independent CASE tools; and CASE toolset and CASE workbenches. Front-end CASE tools facilitate early stages of development -- planning and design activities such as drawing data flow and entity-relationship diagrams, maintaining data dictionaries/depositories, and designing screens and reports (Edwards, 1993; Burch, 1992; Martin, 1991). Examples of front-end CASE tools are: DesignAid II by Transform Logic Corporation, Excelerator by Intersolv Inc., Interactive Easyflow by HavenTree Software Limited, etc. Back-end CASE tools facilitate later stages of development -- logical design, physical design, and construction. They assist in restructuring existing code, analyzing program and database structures, and testing unit and system code. Examples of back-end CASE tools are: Brackets by Optima, Inc., Micro Focus by Micro Focus Inc., Netron/Cap by Netron, Inc., etc.

Forward and reverse engineering CASE tools support some front and back-end systems development activities. The former can be used to automatically generate database schemas and/or procedural code from an entity-relationship diagram. The latter, on the other hand, can be used to reconstruct logical models from program codes or database schemas. The DBMS CASE tools developed by Bachman Inc. is an example of forward engineering tools.

Full life-cycle or integrated CASE (ICASE) support all stages of system development activities -- from logical and physical design to code construction to testing (Banker and Kauffman, 1991). Foundation by Arthur Andersen & Co., Navigator by Ernst and Young, Information Engineering Workbench (IEW) by KnowledgeWare Inc., and Information Engineering Facility (IEF) by Texas Instruments Inc. are some examples of integrated CASE tools.

Methodology dependent CASE tools can be used only when following a particular methodology of systems development for which they were created. For example, Analyst by Tektronix Inc. supports Yourdon/DeMarco Structured Analysis methodology, while VS-Designer by Visual Software, Inc., which is an integrated set of CASE tools, is capable of implementing Yourdon/DeMarco Structured Analysis, Information Engineering (Martin), Entity-Relationship, Warnier-Orr, and Jackson design methodologies. Methodology independent CASE tools are independent of any particular methodology and can be used in systems development following any methodology. Cognos Powerhouse by Cognos, Inc., DEC CASE by Digital Equipment Corporation, Excelerator by Intersolv, Inc. are some examples of methodology independent or methodology neutral CASE tools.

CASE workbenches are integrated tools that automate a number of the phases of the software development life-cycle. CASE toolkits are a collection of tools that focus on providing support for one particular phase of software development.

In an evaluation of vendor CASE products, Vessey, Jarvenpaa, and Tractinsky (1992) provide another classification of CASE tools -- one based on the latitude the tools provide to users in enforcing a methodology. A restrictive CASE tool is one that lets a user use it in a normative manner. FreeFlow (Macintosh) by Iconix Software Engineering, Teamwork by Cadre Technologies, Visible Analyst by Visible Systems Corporation and Silverrun (Macintosh) by XA Systems fall in this category. A guided CASE tool is one that encourages, but does not force the user to use it in a normative manner. Examples of this type of CASE tools are: System Architect by Popkin Software and Systems, Anatool (Macintosh) by Advanced Logical Software, and Deft (Macintosh) by Deft Inc. A flexible CASE tool provides complete freedom to the user in using it. IEW by Knowledge Ware Inc., Foundation Design/1 by Arthur Andersen and Co., Automate Plus by LBMS, Excelerator by Index Technology, and DesignAid by NASTEC are some examples of flexible CASE tools.

3.3.3 CASE -- A Type II Technology

CASE tools, in general, impose a large knowledge burden on users. Months of training may be necessary before a user can gain a basic level of competency. CASE is also a user interdependent technology. The larger the use base for a CASE, the more likely that more complementary products will be available to the users of that CASE tool. Thus, according to Fichman's (1992) framework, CASE is a type II technology. Since organizational learning variables are likely to play a bigger role in the diffusion of type II technologies, CASE seems a good candidate to test our research model.

3.4 Variables in the Model and Hypotheses Generation

This section describes the variables used in the research model and the hypotheses developed for empirical testing.

3.4.1 Characteristics of IS Personnel

Kwon and Zmud (1987) identify role involvement, job tenure, education, and cosmopolitanism as important individual characteristics that may influence diffusion of a technology in organizations. Recent studies of CASE use and adoption in organizations by Finlay and Mitchell (1994) and Orlikowski (1993) show that other characteristics of IS personnel may be important as well in determining diffusion behavior in organizations.

CASE automates many of the manual work procedures used in systems development and can lead to significant changes in work practices and procedures. IS personnel' resistance to change due to changes in work procedures and possible loss of jobs as a result of automation may be a major inhibiting factor in the use of CASE. They may also see the introduction of CASE as providing with fewer opportunities for use and development of their individual skills. IS personnel' perception of use of CASE tools as "deskilling" technology may have a good deal of bearing on their decision to adopt CASE tools (Finlay and Mitchell, 1994; Orlikowski, 1988, 1993; Vipond, 1990). This perception, however, may be tempered by their prior experience in systems development and their career orientation (Finlay and Mitchell, 1994; Orlikowski, 1993).

3.4.1.1 Prior Experience of IS Personnel

Prior experience with an old technology makes one less receptive to a new technology that is incompatible with the old technology.

> "What an individual learns in an organization is very much dependent on what is already known to (or believed by) other members of the organization and what kinds of information are present in the organizational environment." (Simon, 1991, p. 125)

Past research shows that organizations have problems overcoming competencies they have developed with earlier technologies (Whetten, 1987), more so if the organizations have experienced favorable outcomes with the technology, even when the technology is inferior (Levitt and March, 1988).

CASE tools can be either methodology dependent or methodology independent. If CASE tool being considered by organization is methodology dependent, IS personnel experienced in that methodology (either in the present organization or previous employment) will be more likely to adopt such a CASE tool as the new knowledge to be acquired is compatible with their past knowledge. However, if the IS personnel have had experience with a methodology that is different from the one(s) used by the CASE tool, they will be resistant to the tool as the knowledge to be acquired is incompatible with their past knowledge. Such IS personnel will continue to resist the use of methodology-incompatible CASE tools even after they have been adopted by the organization, and may finally decide to leave the organization. This leads to hypotheses:

H1-2: Prior experience of the IS personnel with a compatible methodology will be positively related to the adoption and infusion of CASE tools by the ISD.

3.4.1.2 Career Orientation of IS Personnel

Rogers (1983) states that the more an innovation is perceived as consistent with the needs of the potential adopter, the more likely it is that it will be adopted. There is evidence that IS personnel may be less concerned with the impact of CASE tools on the overall productivity of the IS department or the effectiveness of particular projects (Orlikowski, 1993). Rather they may be more concerned with achieving their own aspirations, both in the short term (acquiring particular knowledge or specific experience) and the long term (attaining career goals, either within the organization or outside the organization). Such aspirations will make them favor those events which provide learning opportunities that assist their aspirations and resist those interventions that oppose them (their aspirations). The IS personnel who see their career in IS (as system designers, analysts, or managers) may perceive CASE tools as a threat to their hard earned skills (such as knowledge of operating systems, programming languages, etc.) and experience with specific hardware and software systems. They may perceive that their marketability will be diminished by the proliferation of CASE tools; they may fear that demand for technical expertise would decline as a result. They may also perceive that capability of CASE tools to automate systems development tasks will limit the possibility of learning new skills. Thus, they will resist the use of CASE tools. We expect this to affect both adoption and infusion phases as technically oriented IS personnel will continue to resist the use of CASE tools as they find the tools incompatible with their career goals. In fact Finlay and Mitchell (1994) note that such individuals may finally decide to leave the organizations as frustrations mount.

The IS personnel who do not see their careers in systems design or IS management but in general management may not see use of CASE tools as threatening their skills or marketability. They rather may welcome relief from the tedium and complexity associated with the technical details of developing application systems. They might see CASE tools expediting their work and allowing them to spend more time on tasks such as business analysis. Hence, we hypothesize:

H3-4: Compatible (managerial) career orientation of IS personnel will be positively related to the adoption and infusion of CASE.

3.4.1.3 Turnover[1]

In the systems development business, there is a very high turnover of IS personnel. The industry average has been reported to be around 25% (Orlikowski, 1993). Whenever a person leaves, the ISD is likely to lose a part of the overall knowledge needed for systems development work and also his/her expertise. As long as the knowledge possessed by the leaving individual(s) is adequately recorded in the organizational memory, the turnover may not have any substantial impact on the systems development work. Unfortunately, as Levitt and March (1988) point out, "a good deal of experience goes unrecorded because the costs are too great." Also, it is difficult to record "soft" knowledge which the leaving individual(s) may have possessed. The end result is that knowledge disappears from the organization's active memory (Neustadt and May, 1986). It may take substantial time and effort to instill the lost knowledge in other individuals afresh. Thus, momentum of CASE diffusion is likely to be lost, at least temporarily, in the event of high turnover.

However, the turnover of IS personnel may affect the IS organization in a positive

[1]Although turnover is an organizational memory factor, we discuss it here to maintain the flow of the discussion.

way, too. As we have seen before, some IS personnel may have experience with a development methodology which is incompatible with the CASE technology being used. These individuals are likely to resist adoption of CASE as the knowledge they possess is "not useful". In this scenario, the organization is likely to benefit from the loss of "obsolete and not useful" knowledge. Thus turnover of these individuals is likely to have a benevolent effect on the diffusion process. We have also seen before that IS personnel who are technically oriented and have limited understanding of the linkage between IT and business are more likely to resist the use of CASE. If these individual leave the organization, the diffusion process will likely benefit. On the other hand, turnover of managerially oriented individuals may negatively affect the diffusion process. Hence, we hypothesize:

H5-6: Turnover of IS personnel with a managerial orientation and good understanding of the linkage between IT and business will be negatively related to adoption and infusion of CASE.

H7-8: Turnover of IS personnel with a technical orientation and limited understanding of the linkage between IT and business will be positively related to the adoption and infusion of CASE.

3.4.1.4 Multi-skilled IS Personnel

If ISD consists of many multi-skilled personnel, the continuity of projects may not be unduly affected even in the case of high relevant turnover (that is, turnover of IS personnel with a managerial orientation and good understanding of the linkage between IT and business). Finlay and Mitchell (1994) in their study on use and adoption of CASE report about the use of SWAT teams (Staff With Advanced Tools). In such teams, each individual is expected to do every task in the project life cycle, but s/he is not expected to be a specialist in all tasks. Instead, SWAT teams of two or three people have one member who is very skilled in analysis, one in programming, and perhaps one in design. Each leads and assists the others in the skill in which s/he is most proficient. In the event one member decides to leave, others may compensate for him/her in the short run, and the continuity of the project may not be adversely affected.

Multi-skilled individuals should make it possible to construct teams which are akin to SWAT teams. We, thus, expect the availability of multi-skilled IS personnel will smooth the transition period in which the lost expertise (because of turnover) is being developed. Presence of multi-skilled individuals may also promote and enhance team work as team members must help each other in getting things done. Their presence will be most useful when CASE technology is being put to its fullest use (that is, infusion) and when minimal interruption will adversely affect its effective use in the organization. Presence of these individuals should not affect adoption of CASE as at that point in the diffusion process, organizations are still experimenting with CASE and the organizational resources are just being committed to CASE usage.

Hence, we hypothesize:

H9: Presence of multi-skilled IS personnel in an ISD will be positively related to the infusion of CASE in case of relevant turnover.

H10: Presence of multi-skilled IS personnel in an ISD will not be related to the adoption of CASE in case of relevant turnover.

3.4.2 Technology Characteristics

Cooper and Zmud (1990) state that the lack of attention to IT technological characteristics is a serious deficiency in most IT implementation research. Keeping this in mind, three technological characteristics -- relative advantage, complexity, and stability of CASE are examined in this study.

3.4.2.1 Relative Advantage

Relative advantage is the degree to which an innovation is perceived as providing greater organizational benefits than either other innovations or *status quo* (Kwon and Zmud, 1987). The use of CASE is seen by many organizations as a means to improve the consistency, repeatability, and definition of their software process (Norman and Nunamaker, 1989). CASE tools are making it possible to enforce design rule checking, enhance team efforts through coordination, and unlinearize the development process so that it is more consistent with the way people really think and work (Forte and Norman, 1992). It is thought to be an especially valuable means to increase productivity of information systems development activities (Banker and Kauffman, 1991; Howard, 1990; Norman and Nunamaker, 1988; Stamps, 1987; Robinson, 1992; Swanson, et al., 1991), improve quality of systems (Howard, 1990), and ease the software development and maintenance burden threatening to overwhelm ISDs (Bachman, 1988; Banker and Kauffman, 1991; Robinson, 1992; Swanson, et al., 1991).

In a competitive market the potential to derive competitive advantage from a new technology provides significant impetus to use the new technology (Gatignon and Robertson, 1989). Thus, an organization which perceives CASE to be advantageous over the current systems development technology, is more likely to adopt it. They also may realize the need to integrate CASE within their IS applications to realize its full benefits.

H11-12: Perceived relative advantage of CASE technology over existing systems development technology will be positively related to adoption and infusion of CASE.

3.4.2.2 Complexity

Complexity is the degree of difficulty users experience in understanding and using an innovation. Lack of skill and knowledge is believed to be a primary factor behind efforts to resist innovations. Unless adopters and users have high needs for growth and achievement, complexity is likely to be associated negatively to adoption (Cooper and Zmud, 1990; Kwon and Zmud, 1987).

CASE tools in general are complex in nature. Their complexity in part derives from their ability to aid in and coordinate some or all the phases of systems development life cycle and enforce engineering standards on all the procedures involved. Increased complexity places higher cognitive burden on IS personnel and may deter them from using CASE tools.

Thus, if a CASE tool is perceived to be hard to use and its underlying concepts and methodologies are perceived to be complex, then it is less likely that adoption will occur. The perceived complexity may deter IS personnel even later in the diffusion process when ISD has already adopted CASE and has mandated its use in all systems development works. Hence, we hypothesize:

H13-14: Perceived complexity of CASE tools will be negatively related to CASE adoption and infusion.

3.4.2.3 Stability

It has been observed that IS personnel are not willing to use a software product which is not bug-free, crash-proof and generally proven competent in the market by others. This is one reason why many adopters delay the acquisition of an innovation (Brown, 1981).

Similarly, the stability of CASE toolset is an important consideration in its usage (Finlay and Mitchell, 1994). In the initial period of CASE tool experimentation, frequent changes to the toolset may have an unsettling effect on developers, while a stable toolset may boost their confidence in using it. Hence, we hypothesize:

H15: Stability of CASE toolset will be positively related to its adoption.

If CASE has been adopted by an organization, it is quite likely that either adopted CASE tool was stable, or enough expertise was available within the organization or from vendors to address this problem. Stability, therefore, is not likely to affect later stages of diffusion. Hence, we hypothesize:

H16: Stability of CASE toolset will not be related to its infusion.

3.4.3 Knowledge Acquisition Factors

Knowledge acquisition is the process by which knowledge to use a new technology, procedure, or routine is obtained. Learning organizations continually invest a good amount of resources in acquiring new knowledge both to keep themselves cognizant of new opportunities and to exploit these opportunities efficiently and effectively. Dore (1973), Dore and Sako (1989), and Sako (1992) remark that although there is no blueprint for learning organizations, they do exhibit many similar characteristics. For example, there is heavy emphasis in such organizations on training and human resource development to facilitate continuous learning.

3.4.3.1 Training and Human Resources Development

Orlikowski (1993)'s study of CASE usage and adoption in two organization shows that the resistance of IS personnel to CASE usage because of their prior experience with incompatible methodology and/or technical orientation can be overcome by investing in human resources development and training. Investment in human resource development helps IS personnel acquire the skills they are deficient in. Such training also helps diffuse fear they may have using new technologies. Thus, old IS personnel can be trained and educated about CASE technology. The users of the application systems developed by ISD can also be educated about the benefits of using CASE tools in systems development such as enhanced quality, increased productivity, and shorter delivery time. This kind of education and training should make skeptical IS personnel more receptive to using and adopting CASE tools.

We expect training to affect not only the adoption phase but also infusion phase of diffusion. It should be noted that content of training is likely to be different in two phases. During the adoption phase, the training may emphasize educating IS personnel about the benefits of CASE. It is likely that in later phases team work and improved developer-user interactions will be emphasized. This should make IS personnel adept at not only understanding users' needs but also involving them more in systems development process. Finlay and Mitchell (1994) have noticed the need for such training. Thus, we hypothesize:

H17-18: Training and human resources development of IS personnel will be positively related to adoption and infusion of CASE.

3.4.3.2 Support of Mediating Institutions

Organizations attempt to learn about technologies, strategies, and administrative practices of other organizations (Czepiel, 1975; Sahal, 1982). "...Manufacturers such as automobile and computer companies have for years routinely examined in detail their competitors' products as they appear in the marketplace." (Eells and Nehemiks, 1984) Usually, organizations acquire this kind of information through consultants, professional meetings, trade shows, publications, etc. However, Attewell (1992) suggests that technical know-how underlying complex technology may be relatively immobile and often has to be recreated by adopting organizations. This burden of developing technical know-how *in situ* becomes a hurdle to adoption.

Mediating institutions (vendors, consultants, etc.) can help adopting organizations lowering these knowledge hurdles. These institutions usually have the opportunity of learning through repetition (by the time a vendor has installed its tenth CASE toolset or a written its tenth compiler, it may have ironed out errors and learned from earlier attempts). On the contrary, few adopting organizations have such an option. There is evidence that support of mediating institutions may be an important factor in the early phase of diffusion process, that is, in adoption of CASE technology (Finlay and Mitchell, 1994). However, as experience is gained and internal technical expertise is developed, the use of mediating institutions may diminish. Thus, by the time innovation reaches infusion phase, support of mediating institutions may not be that important. Thus, we hypothesize:

H19: Support of mediating institutions will be positively related to adoption of CASE.

H20: Support of mediating institutions will not be related to infusion of CASE.

3.4.3.3 Environmental Scanning

Organizational environments change. If the lack of fit between an organization and its environment becomes too great, the organization either fails to survive or undergoes a costly transformation (Miller and Friesen, 1980a, 1980b; Tushman and Romanelli, 1985). In recognition of this, organizations scan their environments for information about changes (Wilensky, 1967; Fahey, King, and Narayan, 1981); they scan their external (and internal) environments in order to identify problems and opportunities (Hambrick, 1982; Stubbart, 1982).

Some information acquisition is for the purpose of identifying alternatives for solving a problem or exploiting an opportunity (Huber and Daft, 1987). Thus, it is likely that an organization facing a backlog, decreased productivity, and diminished quality in systems development will scan for an alternative methodology and technology to solve these problems. ".. the organization will search for additional alternatives when the consequences of the present alternatives do not satisfy its goals." (Feldman and Kanter, 1965, p. 622) Many CASE tools use (radically) different methodology for systems development by automating selected tasks and enforcing an engineering standard. Their use has shown to increase productivity many-fold and improve quality of finished products. Scanning the environment for systems development technology is, therefore, likely to promote the adoption and infusion of CASE. Hence, we hypothesize:

H21-22: Environmental scanning for systems development technology will be positively related to the adoption and infusion of CASE technology.

3.4.4 Information Distribution Factors

Information distribution is a determinant of both the occurrence and breadth of organizational learning (Huber, 1991). Organizational components develop new information by piecing together items of information that they obtain from other organizational units. One organizational process that facilitates the coupling of those who need information, particularly non-routine information, and those who have it is internal employee transfer or job/role rotation.

3.4.4.1 Job/Role Rotation

Job/role rotation not only widens the skills and experience of individual employees, it also brings new knowledge to the unit where the employee is transferred. Combining information from different subunits leads not only to new information but also to new understanding in the organization. Huber (1991) states that it is reasonable to conclude that more learning occurs when more of the organization's units understand the nature of the various interpretations held by other units. More complete understanding can increase cooperation and thus increase the range of potential behaviors.

It has been seen that the induction of CASE failed in many organizations because IS personnel although working under the umbrella of IS function but located in different functional areas did not appreciate its advantage (Orlikowski, 1993). Such IS personnel are more likely to have their allegiance to the functional area they are located in than to the IS function. If such IS personnel are internally transferred and assigned different jobs/roles in systems development, they will be not only more understanding of the use of CASE, but also appreciative of the viewpoints of different functional areas, leading to a better sharing of knowledge about CASE throughout the organization. We expect that this process will aid in both the adoption and infusion of CASE technology.

H23-24: Job/role rotation of IS personnel will be positively related to both adoption and infusion of CASE.

3.4.5 Information Interpretation Factors

Information interpretation is the process by which distributed information is given one or more commonly understood interpretations. Daft and Weick (1984) define interpretation as "the process through which information is given meaning" (p. 294) and also as "the process of translating events and developing shared understandings and conceptual schemes." (p. 286) As discussed in Chapter II, there are many factors which may affect the extent of shared interpretation of new information. Richness of the media used to convey the information is one such factor (Daft and Lengel, 1986).

3.4.5.1 Media Richness of Communication Channels

Media richness is a determinant of the extent to which information is given common meaning by the sender and receiver of the message. It is defined as the communication "medium's capacity to change mental representations within a specific time interval." (Daft and Lengel, 1984; Daft and Huber, 1987, p. 14) Past research supports the notion that managers who consider media richness when choosing a communication medium are more effective (Daft, Lengel, and Trevino, 1987), and thus provides some support for the idea that media richness affects the development of common understanding.

It can be expected that organizations that use richer media in communicating the advantages of CASE in systems development work will be able to forge a better understanding not only among IS personnel, but also among users whose cooperation may be vital. Such an understanding may facilitate adoption of CASE. The media richness should also be an influencing factor in the infusion phase of CASE diffusion when an organization is engaged in using capabilities of CASE to its maximum potential. Hence, we hypothesize:

H25-26: Media richness of communication channels for sharing knowledge about CASE technology will be positively related to its adoption and infusion.

Table 3-1 summarizes the hypothesized relationships between different independent and dependent variables. Operationalization of these variables is discussed in the next chapter.

Table 3-1. Summary of Hypothesized Relationships

Independent Variables	Hypothesized Relationship with Dependent Variables		Related Hypotheses
	Adoption	Infusion	
Prior experience of IS personnel	Positive	Positive	Hypotheses 1-2
Career orientation compatibility of IS personnel	Positive	Positive	Hypotheses 3-4
Multiskilled IS personnel	Not Related	Positive	Hypotheses 9-10
Perceived relative advantage	Positive	Positive	Hypotheses 11-12
Perceived complexity	Negative	Negative	Hypotheses 13-14
Stability of CASE toolset	Positive	Not Related	Hypothesis 15-16
Training and human resources development	Positive	Positive	Hypotheses 17-18
Support of mediating institutions	Positive	Not Related	Hypotheses 19-20
Environment scanning	Positive	Positive	Hypotheses 21-22
Job/role rotation	Positive	Positive	Hypotheses 23-24
Media richness of communication channels	Positive	Positive	Hypotheses 25-26
Turnover of (managerial) IS personnel	Negative	Negative	Hypotheses 5-6
Turnover of (technical) IS personnel	Positive	Positive	Hypotheses 7-8

CHAPTER IV
RESEARCH METHODOLOGY

This chapter describes the research methodology used in this study. It discusses the rationale for using a survey method for data collection. Following this it describes the instrument development process for different dependent and independent variables and the details of conducting the survey. Next, it discusses reliability and validity of the constructs used in the research model.

4.1 Rationale for Using Survey Method

Based on a number of factors, it was decided that a survey method is the most appropriate method to collect data for this study. First, the research undertaken is exploratory in nature. Much of the prior work in the IS literature endorses the use of survey method for exploratory studies. Second, the objective of this study is to determine the relevance and significance of the variables chosen in the context of CASE diffusion. A larger statistically testable sample which is often associated with the survey method should facilitate this objective. Third, much of the work in this study draws on the innovation literature which endorses the use of survey methodology (see Table 2-5) as it permits replicability, generalizability, analyzability, and cross study comparability (Tornatzky and Klein, 1982).

The following sections describe the instrument development process for various dependent and independent variables in the research model.

4.2 Instrument Development

According to Benbasat (1991) and Zmud and Boynton (1991) researchers should first find measures of the research variables in past studies and in relevant reference disciplines (such as organizational behavior and organizational theory, etc). If measures for the variables of interest are not found, only then one should develop one's own instrument. A review of the literature showed that many of the constructs used in this study have not been operationalized previously. The ones that have been operationalized in past studies were adapted to fit the context of this study. Additional items were added to these instruments when recent research indicated they did not fully capture the domain of the construct(s) they were intended to measure. When such instruments were not available, they were constructed following the procedure (see Figure 4-1) advocated by Churchill (1979) and Nunnally (1978) and recently applied by others (Joshi, 1989; Mahmood and Soon, 1991; Sethi and King, 1991).

In general, the procedure for developing the measurement instrument for various constructs involved the following steps:

1. Specification of the domain of the construct: In this step, the construct was defined both constitutively (where appropriate) and operationally. A constitutive definition defines a construct in terms of other construct(s). For example, "turnover" of IS employees may be defined as their "leaving" the organization. An operational definition assigns meaning to measure the construct. An operational definition expresses only limited meaning because an abstract concept can be operationalized and measured in an almost infinite ways (Sethi and King, 1991). Thus, there is the need for the constitutive

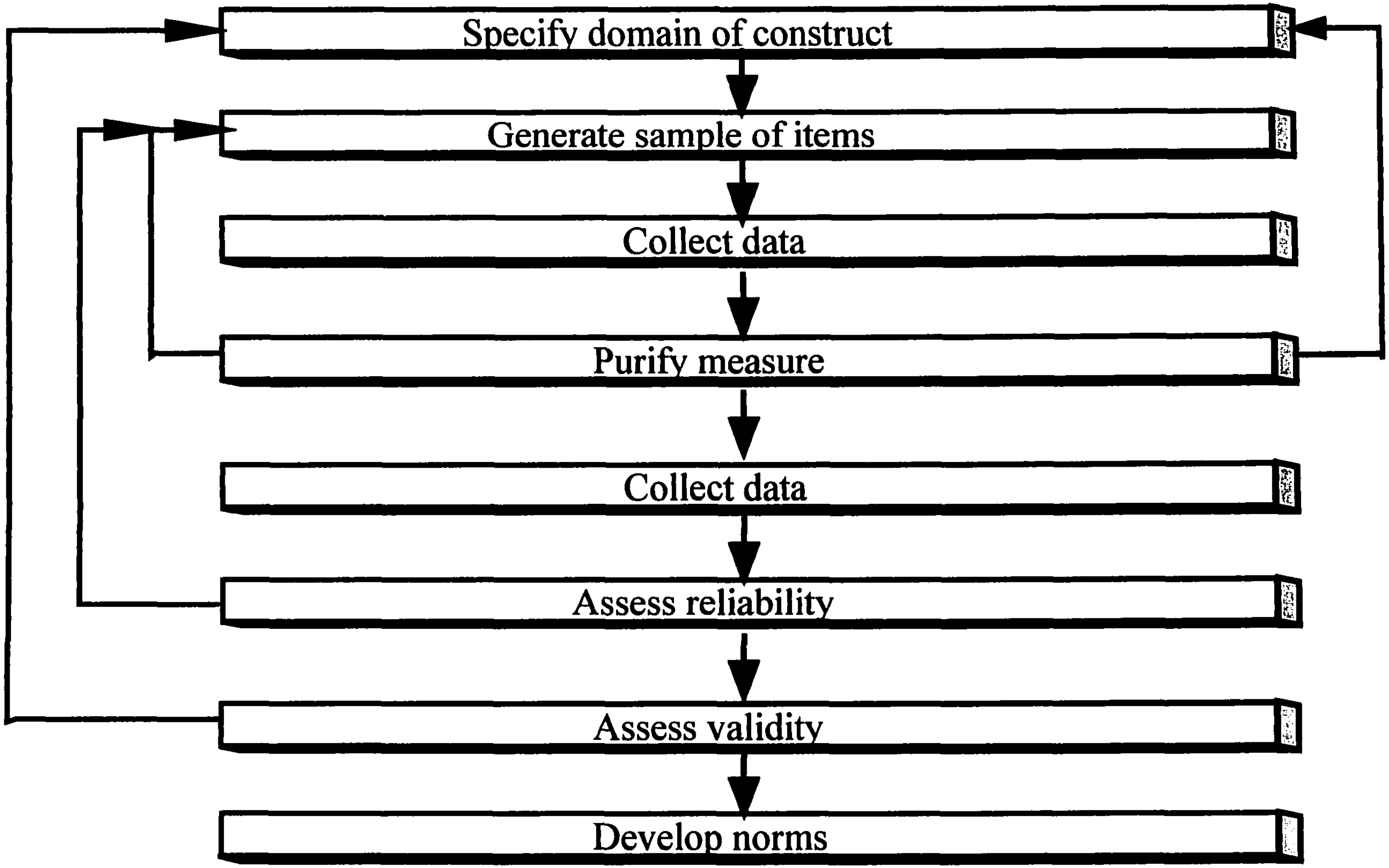

Figure 4-1. Procedure for Developing Measures (Churchill, 1979)

definition whose generality and abstractness preserve a construct's meaning.

2.Generation of sample items: In this step, items were generated from a literature survey (Selltiz, et al., 1976) to capture the domain of the construct including its dimensions, if any. As suggested by Churchill (1979), items with different shades of meaning were generated to provide a better foundation for the eventual measure. After creation of items for each construct, each item was reviewed to make its wording as precise as possible. Double-barreled statements were split into two single-idea statements. If this proved impossible, these statements were eliminated. Some of the statements were stated positively, while the others were stated negatively to reduce respondents' "yea-" or "nay-" saying tendencies (Churchill, 1979).

3. Collection of data: In this step, a survey method was used to collect data. Details of the survey method are discussed later in this chapter in section 4.5.

4. Purification of measure: After the creation of the item pool in step 2 and collection of data in step 3, the instrument was purified using the domain sampling model. This model holds that the purpose of any particular measurement is to estimate the score that would be obtained if all the items in the domain were used (Nunnally, 1978). The score that any subject would obtain over the whole sample domain is the person's true score. However, in practice, one does not use all the items that could be used, but only a sample of them which is representative of the entire domain. A measure is said to be a good measure if the correlation of the sample of items is high with true scores. If all the items in a measure are drawn from the domain of a single construct, responses to those items should be highly intercorrelated. The recommended measure of this internal consistency of a

measure is coefficient alpha. However, the alpha coefficient provides an unbiased estimate only if the scale is unidimensional.

Factor analysis was used to examine the dimensionality of the construct (Nunnally, 1978). Churchill (1979) suggests that factor analysis should be done after eliminating "garbage items" from the measurement instrument through iterative computation of alpha coefficient. Otherwise, there is a tendency to produce many more dimensions, which are generally uninterpretable, than conceptually identified. We followed this strategy. If factor analysis of items measuring a construct showed more than one interpretable dimensions, coefficient alpha was computed for each of these dimensions.

Of the other steps advocated by Churchill (1979) -- collection of data after purification of the measure, assessment of reliability with new data, assessment of validity, and development of norms, only assessment of validity was done (see section 4.7) because of resource constraints. Sethi and King (1991) recognize this limitation and point out that it may not be possible to execute all the steps of construct development in a single study. However, this study conforms to the minimum standards suggested by Churchill (1979) that construct development should proceed at least through the step involving purification of the measure as this can be accomplished with one-time, cross-sectional data.

4.3 Dependent Variables

Both dependent variables, adoption and infusion, have been operationalized in past studies. However, these operationalizations suffer from many shortcomings (discussed below). In this study, we have made an effort to address some of these shortcomings. Below we discuss the operationalization of these variables in detail.

4.3.1 Adoption

The definition of adoption is adapted from Cooper and Zmud (1990). *Adoption* is defined as that stage of diffusion wherein negotiations are made to get organizational backing for implementation of CASE and a decision to invest resources necessary to accommodate the change effort is reached. Past studies of technological diffusion have been marred by the inappropriate operationalization of adoption. In most studies, the dependent variable -- the adoption of an innovation, is an insensitive measure of the consequences of innovation as it is treated as dichotomous (1 = adoption, 0 = non-adoption) and ignores partial adoption. Bayer and Melone (1988) suggest use of multi-item measures to capture the adoption more fully. Downs and Mohr (1976) and Tornatzky and Klein (1982) suggest that implementation of a technology's key features should be used to measure the level of that technology's usage.

Henderson and Cooprider (1990) have developed a functional model of IS planning and design support technology which can be used to determine key features of CASE technology. In developing the functional model, they adopt a broad definition of CASE that includes a wide range of planning and design activities. According to their study, CASE technology has three functional dimensions: production, coordination, and organization. Production technology is defined as the functionality that directly impacts the capacity of an individual(s) to generate planning or design decisions and subsequent artifacts or products. The production dimension of CASE has three subdimensions: representation, analysis, and transformation. The representation component is defined as the functionality that enables the user to define, describe, or change a definition of an object, relationship or process. This component of representation emphasizes the notion of abstracting or conceptualizing a phenomenon. Functionalities such as process flow diagrams, functional charting, entity modeling, domain set specifications, association or relation mapping, etc., exemplify this component. The analysis component is defined as the functionality that enables the user to explore, simulate, or evaluate alternate representations or models of objects, relationship, or processes. This component of the production dimension reflects problem-solving and decision-making aspects of planning and design. The transformation component is defined as the functionality that executes a significant planning or design task, thereby replacing or substituting for a human designer/planner. This component reflects a straight forward capital/labor substitution. In general, production functionality of CASE technology emphasizes its classic efficiency-enhancing aspect, that is, through the investment in technology, the task of a designer is accomplished with fewer resources (Henderson and Cooprider, 1990, p. 235).

The coordination dimension is defined as the functionality which enables or supports the interactions of multiple agents in the execution of a planning or design task. The use of CASE to reduce the cost of coordination can enable a design team to achieve new levels of efficiency and effectiveness. This dimension of CASE has two subdimensions -- control and cooperative technology. The control component is defined as the functionality that enables the user to plan for and enforce rules, policies, or priorities that will govern or restrict the activities of team members during the planning or design process. Two types of relations appear in the control component -- resource management and access control. Resource management enables a manager to ensure that the behavior of individuals and therefore the resource utilization by the design team is consistent with organizational goals. The capability to budget, to identify a critical path or set of activities, to monitor progress or service levels, or to communicate appropriate goals are examples of this type of activity. Access control includes configuration control, authorization management, and the ability to identify and audit the activity of designers. Cooperative functionality of the coordination dimension is defined as that functionality which enables the user to exchange information with another individual(s) for the purpose of influencing (or affecting) the concept, process, or product of the planning/design team. The cooperative functionalities of CASE reflect the role of CASE technology as both a communication channel and a facilitation aid.

The organizational dimension is defined as that functionality and associated policy or procedures that determine the environment in which production and coordination technology are applied to planning and design processes. This dimension of CASE technology has two components: support and infrastructure. Support component is defined as the functionality to help an individual user understand and use CASE technology effectively. The infrastructure component of organizational technology is defined as the standards that enable portability of skills, knowledge, procedures, or methods across planning or design processes. The need for consistency of the data definition storage structure with emerging standards for a central repository exemplifies this component.

Henderson and Cooprider (1990) have identified ninety-eight distinct functionalities to capture the above three dimensions (and underlying subdimensions) of CASE. Some of these functionalities may belong equally to more than one dimensions.

Keeping in mind the shortcomings of past study and the suggestions of Downs and Mohr (1976) and Tornatzky and Klein (1982), we measure adoption in this study using a response matrix (see Table 4-1). Along one dimension of the matrix are the different functionalities of CASE technology. We have used only twenty-two of the ninety-eight functionalities of Henderson and Cooprider (1990) to represent CASE technology, reflecting the more specific nature of our definition of CASE. Limited length of the questionnaire and the fear of imposing too much cognitive burden on respondents were other reasons not to include more functionalities. We did not designate a given functionality as belonging to a particular dimension or subdimension in the questionnaire.

Out of these twenty-two functionalities, the functionality 1 (counting from the top of the matrix) represents the representation, 2 the analysis, and the functionalities 3-9 represent the transformation (with 3-6 representing forward engineering and 7-9 backward engineering)* subdimensions of the production dimension. The functionalities 10-12 represent the control and 13-15 the cooperation subdimensions of the coordination dimension, while the functionalities 16-20 represent the support and 21-22 the infrastructure subdimensions of the organization dimension.

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*We make a distinction between forward engineering and backward engineering functionalities of the transformation subdimension (although Henderson and Cooprider (1990) do not) as these functionalities facilitate different tasks in systems development (see Chapter III).

Table 4-1. Response Matrix for Measuring Adoption and Infusion

CASE Tool Functionalities	Level of Usage				
	Not used at all	Used on an experimental basis (or in pilot projects)	Used on regular basis by a few people/projects	Used on regular basis by most people/ projects	Used on regular basis by all people/ projects
Representation of objects, relationships, or processes					
Analysis of objects, relationships, or processes					
Automation of planning or design tasks					
Data base code/schema (e.g. IDMS) generation					
Procedural (e.g. COBOL) code generation					
Test data generation					
Analysis of program structure					
Automatic restructuring of program code					
Analysis of data base structure					
Enforcement of rules, policies, or priorities governing activities of the systems development process					

Table 4-1. Response Matrix for Measuring Adoption and Infusion (continued)

CASE Tool Functionalities	Level of Usage				
	Not used at all	Used on an experimental basis (or in pilot projects)	Used on regular basis by a few people/projects	Used on regular basis by most people/ projects	Used on regular basis by all people/ projects
Resource management: budgeting, scheduling, and tracking					
Access control: auditing, configuration control, and authorization management					
Messaging and electronic communication					
Attaching notes electronically to objects					
Group interaction support (brainstorming, nominal group techniques, etc)					
On-line help for specified commands/features					
Templates for tutorials/demos					
Explanation facility for recommended actions					
Use of domain knowledge to diagnose user problems and recommend appropriate action					

Table 4-1. Response Matrix for Measuring Adoption and Infusion (continued)

CASE Tool Functionalities	Level of Usage				
	Not used at all	Used on an experimental basis (or in pilot projects)	Used on regular basis by a few people/projects	Used on regular basis by most people/ projects	Used on regular basis by all people/ projects
Standardized structures to represent designs					
Consistency of data definition storage structures					
Project repository					

Along the other dimension of the response matrix is the level of usage (0 = not used at all, 1 = used on an experimental basis (or in pilot projects), 2 = used on regular basis by a few people/projects, 3 = used on regular basis by most people/projects, and 4 = used on regular basis by all people/projects). Although a simpler scale could be used (for example, 0 = used, 1 = not used) to capture the adoption by an organization, the use of such a detailed scale serves a dual purpose -- it is also used to capture infusion of CASE (discussed below).

The proportion of the features that are used on or beyond an experiment level by an organization (corresponding to a numerical value of 1 to 4 on the level of usage scale) is taken as a measure of adoption, obtained by the following equations:

$$Adoption = \frac{Production + Coordination + Organization}{3}$$

$$Production = \frac{Representation + Analysis + Transformation}{3}$$

$$Tranformation = \frac{ForwardEngg.Trans. + BackwardEngg.Trans}{2}$$

$$Coordination = \frac{Control + Cooperation}{2}$$

$$Organization = \frac{Support + Infrasructure}{2}$$

where Representation = (no. of functionalities used on or beyond experimental level)/(total no. of functionalities) in the representation subdimension, and so on.

This operationalization of adoption is consistent with Nilakanta and Scamell (1990), Rai (1995), Rai and Howard (1994), and Zmud (1982, 1984). Thus, the least adopted scenario (corresponding to an overall score of 0) will be one in which an organization does not use any of the CASE functionalities. The most adopted scenario (corresponding to an overall score of 1) will be one in which an organization uses all the functionalities on or beyond experimental level of usage. This operationalization incorporates both multi-item measures as advocated by Bayer and Melone (1988) and key features of technology as suggested by Downs and Mohr (1976) and Tornatzky and Klein (1982) to capture the adoption more fully .

4.3.2 Infusion

Cooper and Zmud (1990) define infusion as that stage of diffusion wherein increased organizational effectiveness is obtained by using the technology in a more comprehensive and integrated manner to support higher level aspects of organizational work. Zmud and Apple (1992) define infusion as the extent to which the full potential of the innovation has been embedded within an organization's operational and managerial work systems. We use Zmud and Apple's (1992) definition of infusion in this study.

Sullivan (1985) and Zmud and Apple (1989) suggest that infusion should be related to the importance, impact, or significance of the technology's key functionalities to the organization. In studying diffusion of IEW, an integrated CASE tool in organizations, Wynekoop (1991) states that use of a common repository and CASE tools on all applicable development projects constitutes infusion activities. This view is supported by Case (1985) and Jones (1987) who argue that to realize benefits (that is, increased development efficiency, better software quality, etc) from the adoption of a CASE tool, a common specification database must be used to enable software component reuse, management visibility into projects, on-line reviews, data interchange, and project milestone tracking. Thus, a CASE tool is most effectively used when all team members share a common project repository. In addition, the CASE tool should be used to complete all development projects. Accordingly, Wynekoop (1991) uses the percentage of applicable projects on which IEW is used as a measure of infusion. In reality, a particular project may not use all the features of the CASE tool, and thus use of CASE as a dichotomous variable (1 = use, 0 = no use) may not capture the levels of infusion very well even for a particular project (as opposed to organizational infusion).

We measure infusion as a ratio of sum of scores on all the functionalities (see Table 4-1) used by an ISD on and beyond experimental level of usage (corresponding to a score of 1 to 4) and the maximum total score possible when all the functionalities are used at the highest level of usage (corresponding to a score of 4) as determined by the following equation:

$$\begin{aligned}
Infusion &= \frac{Production + Coordination + Organization}{3} \\
Production &= \frac{Representation + Analysis + Transformation}{3} \\
Tranformation &= \frac{Forward\,Engg.Trans. + Backward\,Engg.Trans}{2} \\
Coordination &= \frac{Control + Cooperation}{2} \\
Organization &= \frac{Support + Infrasructure}{2}
\end{aligned}$$

where Representation = (total score on the functionalities used on or beyond experimental level)/ (maximum possible score on these functionalities) in the representation subdimension, and so on.

Thus, the least infused scenario (corresponding to an overall score of 0) will be one in which an organization does not use any of the CASE functionalities. The most infused scenario (corresponding to an overall score of 1) will be one in which an organization uses all the functionalities at the highest level of usage. This operationalization captures the technology's usage to its full potential in improving systems development task in that the overall score reflects both the extent of use of technology's key features and the extent of usage of each of these features. This concludes the operationalization of dependent variables. The following section describes the operationalization of different independent variables.

4.4 Independent Variables

All the independent variables described in the model are measured by items written in the form of statements with which the respondent is to agree or disagree on a 7-point Likert type scale. Tornatzky and Klein (1982) support such use of perceptual measures for innovation studies. All the constructs which are not operationalized in past studies were measured following the procedure detailed in section 4.2. The ones which are operationalized in the past studies were adapted to fit the context of this research.

4.4.1 Prior Experience of IS Personnel with a Compatible Methodology

A review of literature showed that this construct has not been operationalized previously. However, compatibility has been operationalized by many studies in the innovation diffusion literature. Drawing on Grover (1993) and Moore and Benbasat

(1991), this construct is measured by two items (see Table 4-2).

4.4.2 Career Orientation of IS Personnel

The career orientation of IS personnel is measured by three items synthesized from a review of the IS literature (Finlay and Mitchell, 1994; Orlikowski, 1993).

4.4.3 Multi-skilled IS Personnel

Drawing on Finlay and Mitchell (1994), multi-skilled IS personnel is operationalized by six items.

4.4.4 Perceived Relative Advantage

This construct is operationalized by drawing on Grover (1993), Moore and Benbasat (1991), Premkumar, et al. (1994), and Wynekoop (1991). A consolidation of items from these studies resulted in twelve items (Table 4-2).

4.4.5 Perceived Complexity

Complexity has been operationalized by Grover (1993), Premkumar, et al. (1994), and Wynekoop (1991). Moore and Benbasat (1991) have operationalized a similar construct -- "ease of use" which is defined as opposite of complexity. A consolidation of the items from these studies resulted in five items (Table 4-2).

4.4.6 Stability of CASE Tools

A review of the IS literature showed that stability has not been operationalized previously. However, Srinivasan (1985) has operationalized "system stability" using items which measure response time, error proneness, reliability and accessibility, and availability of the system. Since, in this research, we focus on technological stability of software, only error proneness and reliability were determined to be relevant. A review of

Table 4-2. Operationalization of Independent Variables

Variable	Item No.	Item Description
Prior experience of IS personnel	5	1. In the past, our IS department used the same development methodology as CASE.
	8	2. Before CASE adoption, our IS personnel had experience with a similar methodology as used by CASE.
Career orientation compatibility of IS personnel	21	1. Our IS personnel aspire to be IS managers.
	28	2. Our IS personnel aspire to be in general management.
	42	3. Our IS personnel are managerially (rather than technically) oriented.
Multiskilled IS personnel	6	1. Our IS personnel are involved with limited aspects of systems development.
	11	2. Our IS personnel are involved with multiple phases of systems development (analysis, design, implementation, etc).
	27	3. Our IS personnel are able to work in multiple phases of systems development.
	33	4. IS personnel participate in multiple development tasks in our IS department.
	35	5. IS personnel are typically involved with both front- and back-end activities.
	36	6. Our IS personnel are able to work in limited aspects of systems development.

Table 4-2. Operationalization of Independent Variables (continued)

Variable	Item No.	Item Description
Perceived relative advantage*		We perceived that CASE would:
	1	1. Increase the IS department's productivity.
	2	2. Improve the quality of information systems.
	3	3. Decrease systems delivery time.
	4	4. Decrease systems development time.
	5	5. Reduce maintenance cost.
	6	6. Help the IS department better meet customer needs.
	7	7. Enhance our IS personnel's effectiveness on the job.
	8	8. Make it easier for our IS personnel to do their job.
	9	9. Reduce systems development cost.
	10	10. Increase standardization of systems development procedures.
	11	11. Improve control and coordination of different systems development activities.
	12	12. Decrease systems backlog in the IS department.
Perceived complexity*		We perceived that CASE would:
	13	13. Be much harder to use.
	14	14. Be very complex to use.
	15	15. Be cumbersome to use.
	16	16. Require a lot of mental effort.
	17	17. Be often frustrating to use.

* Items in part II of the questionnaire (see Appendix B). Rest of the items are in part IV.

Table 4-2. Operationalization of Independent Variables (continued)

Variable	Item No.	Item Description
Stability of CASE toolset	1 10 14 15 19	1. The CASE toolset had many bugs during initial usage. 2. Our CASE toolset crashed many times during initial usage. 3. The CASE toolset was stable during initial usage. 4. Integration between various phases of the systems development life-cycle was often problematic during initial usage of CASE. 5. When the CASE toolset was first used, frequent changes were needed to make it work.
Training and human resources development	3 20 24 29 31 34 41	1. Our training and human resource development programs are designed to help IS personnel learn about communications and customer-user interactions. 2. Our IS personnel are trained on a continuous basis to use new systems development methodologies. 3. Training and human resource development are central to our IS department's mission. 4. Our training and human resource development programs are designed to help IS personnel learn about team work. 5. Our IS personnel are trained on a continuous basis to use new systems development tools. 6. Our training and human resource development programs are designed to help IS personnel achieve their full potential. 7. Our training and human resource development programs are designed to assist customers, suppliers, and other stakeholders to learn about systems development tools and methodologies.

Table 4-2. Operationalization of Independent Variables (continued)

Variable	Item No.	Item Description
Support of mediating institutions	2	1. When we first started using CASE, we routinely used help lines provided by vendors.
	4	2. We did not use the services of vendors and consultants after adoption of CASE.
	12	3. Vendors and consultants helped us in installation, maintenance, repair, and troubleshooting activities.
	25	4. When we initially used CASE, vendors and consultants provided us with skilled personnel.
	32	5. Vendors and consultants helped us train our IS personnel in the use of CASE tools.
	39	6. When we first started using CASE, we frequently relied on the expertise of vendors and consultants.
	43	7. We routinely use help lines provided by vendors.
	47	8. Vendors and consultants helped us plan for the integration of CASE tools with existing systems.
Environment scanning	13	1. We routinely gather opinions from our clients about systems development technology.
	23	2. We regularly conduct special market research studies to keep abreast of new and innovative systems development technologies.
	30	3. We routinely participate in professional meetings to keep abreast of new systems development products and processes.
	45	4. We actively keep abreast of new systems development products and processes used by our competitors.
Job/role rotation	1	1. People seldom change job responsibilities in our IS department.
	2	2. We frequently rotate IS personnel among various positions and job roles.

Table 4-2. Operationalization of Independent Variables (continued)

Variable	Item No.	Item Description
Media richness of communication channels	7	1. We use communication media which allow us to share knowledge about CASE technology across geographical boundaries.
	22	2. We use communication media which allow us to simultaneously share knowledge about CASE technology with multiple individuals.
	26	3. We use communication media which provide delayed feedback (e.g. electronic mail) to share knowledge about CASE technology.
	38	4. We use communication media which allow customized messages to share knowledge about CASE technology.
	40	5. We use communication media which allow high variety (e.g. textual, graphic, numeric, etc) to share knowledge about CASE technology.
	44	6. We use communication media which allow multiple cues such as body language, tone of voice, etc (e.g. face-to-face discussion and video-conferencing) to share knowledge about CASE technology.
	48	7. We use communication media which provide quick feedback (e.g. face-to-face discussion and video-conferencing) to share knowledge about CASE technology.
Turnover of (managerial) IS Personnel	9	1. After CASE adoption, turnover among IS personnel with a good understanding of the linkage between IT and business has decreased.
Turnover of (technical) IS Personnel	17	1. After CASE adoption, turnover among systems analysts has increased.
	18	2. After CASE adoption, turnover among IS personnel with limited understanding of business has increased.
	46	3. After CASE adoption, turnover among systems designers has increased.

the literature resulted in three more items (Finlay and Mitchell, 1994).

4.4.7 Training and Human Resources Development of IS Personnel

This construct is operationalized by drawing on Finlay and Mitchell (1994), Orlikowski (1993), Rai (1990), and Sako (1992). Earlier Rai (1990) operationalized a similar construct named "company CASE training" (Cronbach's $\alpha = 0.855$). A close examination at the items measuring this construct shows, however, that it does not measure the learning aspect adequately. Hence, seven items were generated anew from a review of the literature.

4.4.8 Support of Mediating Institution

Attewell (1992) in his study of diffusion of business computing in organizations has introduced the concept of role of mediating institutions. However, this construct was not operationalized in a manner to record a respondent's response in a mail survey as Attewell relied on secondary data for his analysis. Thus, we had to generate items anew for this construct from a review of the literature (Attewell, 1992; Finlay and Mitchell, 1994; Huber, 1992). This construct was operationalized by eight items.

4.4.9 Environmental Scanning

Environmental scanning has been operationalized by Rai (1993). Grover (1993) has operationalized a similar construct called "competitor scanning," while Miller (1987) has operationalized "extent of use of scanning devices to gather information about an organization's environment." A consolidation of items from these studies resulted in four items.

4.4.10 Job/Role Rotation

This construct is operationalized by drawing on Rai (1994). He used a different name called "job stability within the ISD" and measured it by two items (Cronbach's α = 0.725). However, a close look at the items shows that the construct really measures job/role rotation.

4.4.11 Media Richness of Communication Channels

As discussed earlier, media richness is a determinant of the extent to which information is given common meaning by the sender and receiver of the message. Organizations usually process information through many channels. Research shows that these channels are not equal in their capacity for reducing equivocality and giving common meaning. Daft and Lengel (1984) proposed that media selection is closely linked to the amount of equivocality confronting managers. Based on communication channel research (Bodensteiner, 1970; Holland, Stead, and Liebrock, 1976), Daft and Lengel (1986) proposed that media used in organizations can be organized into a hierarchy of richness, where richness is defined as the medium's capacity to change understanding (Daft and Lengel, 1986; Lengel, 1983). According to this perspective, face-to-face interaction is the richest medium, followed by video-phone and video-conferencing, telephone, electronic mail, personally addressed documents such as memos and letters, and formal, unaddressed documents such as bulletins and flyers. The information capacity of these media is presented by Daft and Huber (1986) as a function of four features: (1) opportunity for timely feedback, (2) the ability to convey multiple cues, (3) the tailoring of messages to personal circumstances, and (4) language variety.

Accordingly, media richness of communication channels in this study is assessed using seven items (see Table 4-2) corresponding to these four features.

4.4.12 Turnover of IS Personnel

Our review of the MIS literature showed that this construct has not been operationalized previously. However, in the organizational behavior/organizational theory literature, turnover has been operationalized by Bartol (1979). He measured turnover by asking subjects to check whether they "still work for the same organization" or whether they "now work for a different organization" from the one they did when they completed the previous survey. The survey was conducted in two phases; second phase of mailing was done after one year.

This operationalization of turnover was found inappropriate for this research for two reasons. First, this did not measure turnover at the unit of analysis this research employs, that is, IS department. Second, it involved two phases of mailing. For these reasons, items for this construct were developed anew for this study.

Turnover of IS personnel with managerial orientation is operationalized by one item. Turnover of IS personnel with technical orientation is operationalized by three.

4.5 Mail Survey

This section describes details of the survey conducted to collect data.

4.5.1 Sample Selection

The sample for the study was selected from a database called "Directory of Top Computer Executives." This database keeps records of top IS executives of all the organizations in the U.S., and is available for academic research at a modest price. The database is maintained by Applied Computer Research, Inc., Phoenix, Arizona. As of July 1995 the database included IS executives from 15,060 different organizations (including subsidiaries and branches). The number of IS executives in the database was in excess of 34,000. The database is updated twice every year, and hence its currency is maintained. From this database, 1582 executives from different organizations were selected at random.

4.5.2 Subjects

Huber and Power (1985) argue that if only one informant per organization is to be targeted, the person most knowledgeable about the issue of interest should be selected. The head of information systems department was considered to be the most suitable subject for this research.

4.5.3 Pilot Test

Before mailing the questionnaire (Appendix B), the survey instrument was validated in two stages. In the first stage, three doctoral students in the information systems reviewed the survey instrument for the content coverage of the domain of different constructs. One doctoral student in the production and operations management reviewed the instrument for the clarity of questions asked in the questionnaire. After incorporating their feedback, in the second stage, the instrument was reviewed by four faculty members of a Midwestern university and four IS executives from four different organizations for both content coverage and clarity of the questions asked. Their reviews suggested minor changes, primarily in the wording of questions. These changes were incorporated in the survey instrument. Additional questions were included in part I of the questionnaire to collect demographic and descriptive data about the respondent, his/her organization, and the CASE tools used (if any) by the organization (Appendix B: Part I).

4.5.4 Questionnaire Administration

When administering questionnaires, steps were also taken to minimize method bias and to maximize response rate. To reduce method bias due to proximity of items measuring the same construct, the questions associated with the operationalization of various constructs were randomly scattered in parts II and IV of the questionnaire. To maximize response rate, all the potential respondents were encouraged to respond irrespective of whether their organization was using CASE technology for systems development at the time of survey administration. If a respondent's organization did not use CASE, s/he was asked to provide only select demographic information (the first four questions in the part I of the questionnaire). If a respondent's organization ever considered using CASE and evaluated CASE tool(s) for that purpose, but was not presently using it, s/he was asked to respond to the questions both in part I and part II. If a respondent's organization was using CASE at the time of survey administration, s/he was asked to respond to all the questions.

The survey was sent out to 1582 top IS executives using first class mail. Each survey included a cover letter, a copy of the questionnaire, and a business reply-paid envelope. The cover letter (see Appendix C) briefly described the objective of the study. A pack of coffee was included as a small token of appreciation for completing the questionnaire. As an incentive to the potential respondents, they were promised to be provided with the summary of the study's results. Respondents interested in receiving a summary of the study were asked to provide with their mailing addresses.

Each survey sent out was assigned a unique label which was affixed at the back of the questionnaire. The label was used to keep track of respondent's industry classification. It also provided a convenient means to identify non-respondents for a follow-up mailing.

The first mailing was done on August 11, 1995. This resulted in 193 responses. A follow-up mailing was done on September 9, 1995 (see Appendix D). This resulted in an additional 169 responses. Of the 1582 surveys sent out in the first mailing, sixteen were returned because of incorrect addresses. One was discarded by the respondent as it was addressed to another executive in the same organization, another was returned for the same reason, and nine were not usable. Out of the 1374 reminders, four were returned because of incorrect addresses and one was not usable. Thus, a total of 350 (182+168) usable questionnaires was returned. This represents a response rate of 23.08% (= 100*(350+10)/(1582-20-1-1)). Out of these 350 usable responses, 245 never used CASE, 59 had considered using it at one point in time, but did not use it, while 46 were using it at the time of the survey.

4.6 Reliability

Construct reliability and validity are frequently ignored aspects of MIS survey research (Straub, 1989). In this study, steps (see section 4.2) were taken to ensure that valid and reliable measures were used.

Reliability is the accuracy or precision of a measuring instrument (Kerlinger, 1986). It measures the stability of the scale based on an assessment of the internal consistency of the items measuring the construct (Churchill, 1979).

After cleaning data (see Chapter V), coefficient alpha was computed for each construct in the research model along with the item-to-total correlations in accordance with Churchill's (1979) suggestions. In case of a scale having low coefficient alpha, items with near zero item-to-total correlation and those which produced a substantial or sudden drop in the item-to-total correlation were dropped. The coefficient alpha was calculated for the remaining items for each of the constructs. The process was repeated till a satisfactory alpha coefficient (>= 0.70) (Nunnally, 1978) was achieved. In cases, when there were only two items in a scale, no item was deleted in spite of a low alpha coefficient. In other cases, when only two items were left in a scale, the process was stopped. This was done to avoid creation of one-item measures which is not advised because of difficulty in determining their reliability and validity. The dimensionality of each construct was examined by using principal component factor analysis (Nunnally, 1978) with a varimax rotation. Tabachnick and Fidell (1989) recommend a case to variable ratio of 5:1 as a minimum for factor analysis. This requirement was met for each construct.

An eigenvalue of 1.0 or above was used as a criterion to estimate the number of factors underlying a construct. This estimation was supplemented by a scree-plot of eigenvalues against each obtained factor. Simplicity and interpretability of obtained factors were other criteria to estimate the number of factors. To obtain simple and interpretable factors, items with low loadings (less than 0.35) on all the factors and items with high loadings (greater than 0.35) on more than one factor were dropped. Items that loaded on an uninterpretable factor were also dropped. If a construct had more than one interpretable dimension, coefficient alpha was computed for each dimension.

It should be noted that Cronbach's alpha can be artificially inflated through method bias and a large number of items. In this study, as indicated earlier, an attempt was made to reduce method bias by including both positively and negatively worded items and by dispersing the items measuring a construct throughout the questionnaire.

4.6.1 Prior Experience of IS Personnel with a Compatible Methodology

A computation of item-to-total correlation statistics for the items measuring this construct showed that both items had equal correlation (0.4513) with the total score. Both items were retained. The scale has an alpha coefficient of 0.6218. The standardized item alpha coefficient is 0.6219. A factor analysis of the two items confirmed that the construct has only one dimension, which explained 72.6 percent of the total variance (see Table 4-3).

4.6.2 Career Orientation of IS Personnel

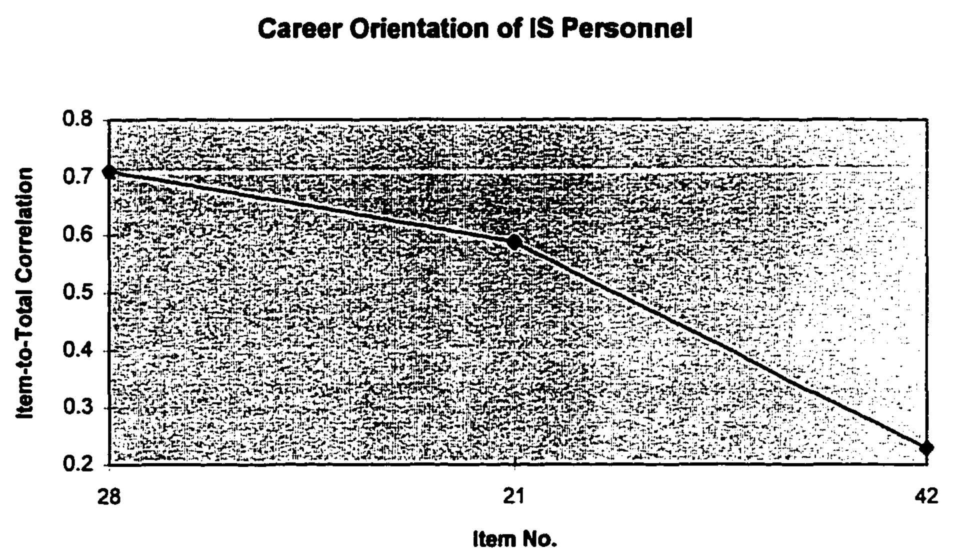
A computation of item-to-total correlation statistics for the three items measuring this construct showed that three items 42, 21, and 28 have item-to-total correlations of 0.2290, 0.5883, and 0.7112 respectively and a coefficient alpha of 0.6742. Although, the scale has a high alpha coefficient (> 0.70), item 42 was deleted as a plot of correlations (Figure 4-2a) of these items in decreasing order of magnitude (Churchill, 1979) showed that there was a substantial drop in correlation from item 21 to 42, and may not belong to this construct. Deletion of item 42 resulted in an increase in alpha coefficient to 0.8393. The standardized item alpha coefficient for the modified scale is 0.8399. A principal

Table 4-3. Cronbach Alphas and Factor Loadings for Various Independent Variables

Variable	Items	Factor Loading	Variance Explained	Cronbach α
Prior Experince of IS Personnel With a Compatible Methodology	5 8	0.8518 0.8518	72.6%	0.6218
Career Orientation of IS Personnel	21 28	0.9284 0.9284	86.2%	0.8393
Multi-Skilled IS Personnel	11 27 33 35	0.8118 0.8592 0.8957 0.8273	72.1%	0.8679
Perceived Relative Advantage				
Capability	2 10 11	0.7918 0.8367 0.8883	72.7%	0.8038
Efficiency	3 4 12	0.7968 0.8455 0.8648		0.7988
Perceived Complexity	13 14 15 17	0.9328 0.8289 0.9140 0.8669	78.6%	0.9087
Stability of CASE Tools	1 10 14 15 19	0.7903 0.8722 0.7020 0.6009 0.8319	58.6%	0.8188
Training and Human Resources Development of IS Personnel	3 20 24 31 41	0.5980 0.8263 0.5231 0.6785 0.7425	46.5%	0.7083

Table 4-3. Cronbach Alphas and Factor Loadings for Various Independent Variables (continued)

Variable	Items	Factor Loading	Variance Explained	Cronbach α
Support of Mediating Instituitions				
In-House Vendor Support	25 32 47	0.8873 0.8004 0.7313	62.6%	0.7540
On-Line Vendor Support	2 4 43	0.8211 0.6112 0.7069		0.5390
Environmental Scanning	13 23 30 45	0.5653 0.6765 0.8935 0.8013	55.4%	0.7067
Job/Role Rotation	16 37	0.7998 0.7998	64.0%	0.4353
Media Richness Of Communication Channels	7 22 26 38 40 44 48	0.7287 0.7659 0.7324 0.8766 0.9085 0.7220 0.8554	64.4%	0.9043
Turnover of (Technical) IS Personnel	17 18 46	0.8792 0.7390 0.7263	71.7%	0.8006



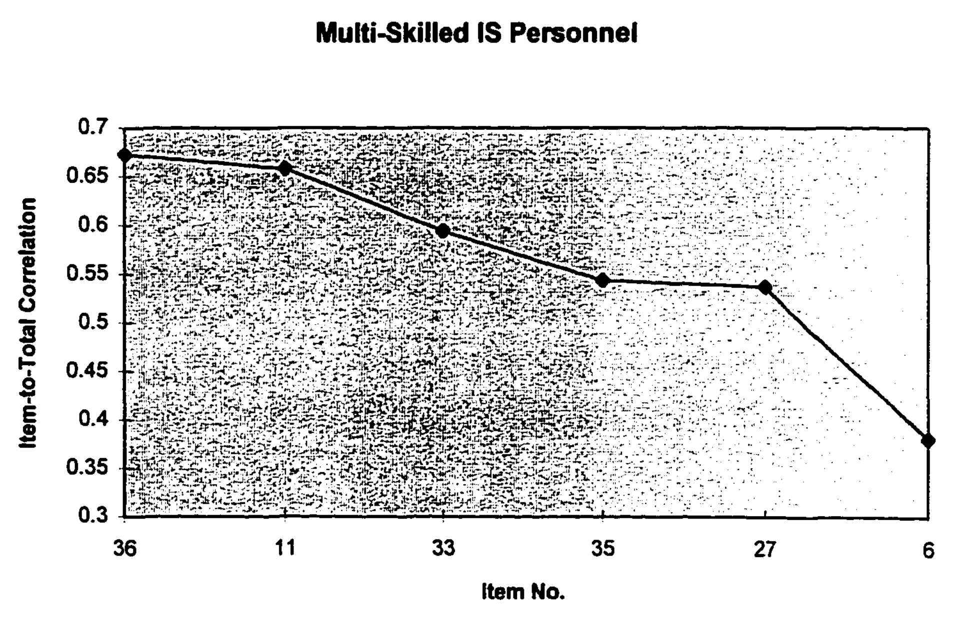


Figure 4-2a. Plot of Item-to-Total Correlations

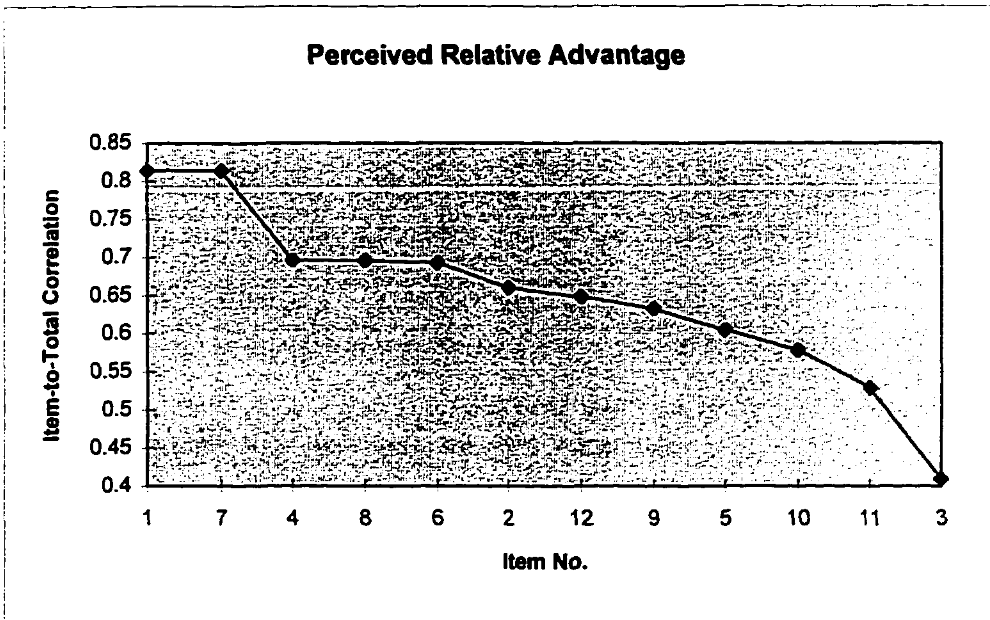
component factor analysis of these items resulted (Table 4-3) in one simple factor explaining 86.2 percent of the total variance.

4.6.3 Multi-skilled IS Personnel

A computation of item-to-total correlation statistics for the items measuring this construct showed that the six items 11, 6, 27, 36, 33, and 35 have item-to-total correlations of 0.6583, 0.3807, 0.5372, 0.6727, 0.5943, and 0.5438 respectively and a coefficient alpha of 0.7609. Item 6 was deleted as it showed a substantial drop in correlation from the other five items (see Figure 4-2a) suggesting that it may not belong to this construct. The coefficient alpha for the remaining items on the scale is 0.8215. A plot of the item-to-total correlation for the remaining items showed a substantial drop in correlation of item 36 from the other four items, and was dropped. The coefficient alpha for the remaining items on the scale is 0.8679. The standardized item alpha coefficient is 0.8705. A factor analysis of these items resulted (Table 4-3) in a single factor explaining 72.1 percent of the total variance.

4.6.4 Perceived Relative Advantage

A computation of item-to-total correlation statistics for the items measuring this construct showed that the twelve items 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12 (see Table 4-2, item description numbers) have item-to-total correlations of 0.8133, 0.6503, 0.4162, 0.6965, 0.6033, 0.6902, 0.8108, 0.6957, 0.6330, 0.5729, 0.5223, and 0.6491 respectively and a coefficient alpha of 0.9104. A plot of the these correlations in decreasing order of magnitude suggested (see Figure 4-2b) that there was substantial drop in correlation from item 7 to 4 and then again from 11 to 3. The plot also shows that items 1 and 7 form one



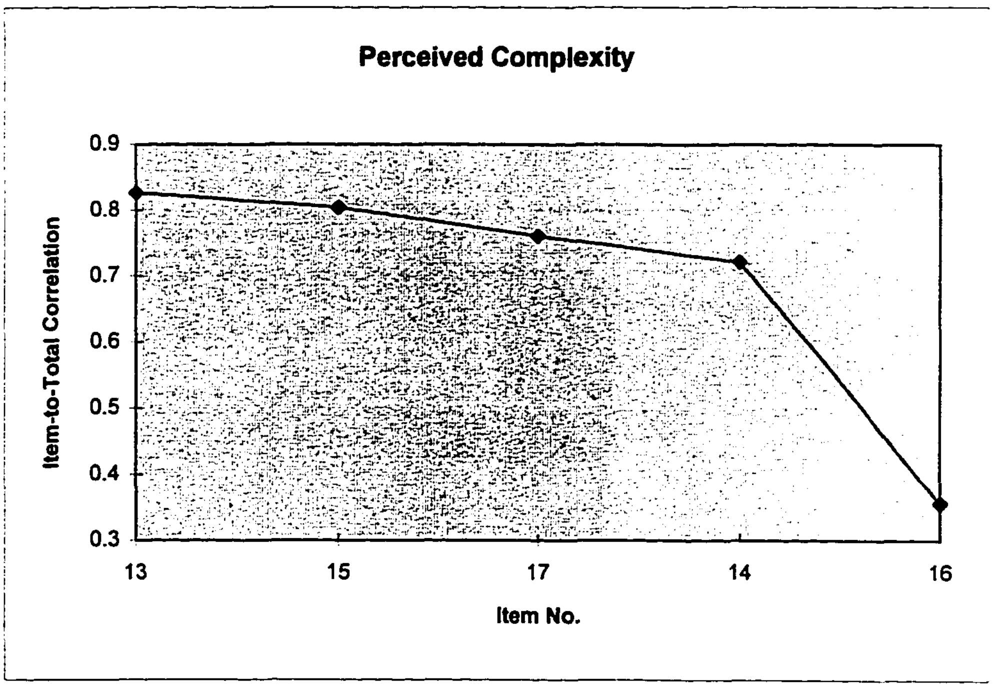


Figure 4-2b. Plot of Item-to-Total Correlations

cluster, while items 4, 8, 6, 2, 12, 9, and 5 form another cluster, indicating that construct may not be unidimensional.

A factor analysis of these items resulted in two factors explaining 64.7 percent of the total variance. Items 1, 5, 6, 7, and 8 were dropped as they loaded heavily (more than 0.35) on more than one factor. The remaining items were again factor analyzed resulting in two factors explaining 69.8 percent of the total variance. Item 9 loaded heavily on the two factor and was dropped. The remaining items were again factor analyzed resulting in two simple and interpretable factors (Table 4-3) explaining 72.7 percent of the total variance. Items 2, 10, and 11 loaded on one factor (henceforth to be called Capability) emphasizing the enhancement capability of CASE technology. Items 3, 4, and 12 loaded on the other factor (henceforth to be called Efficiency) emphasizing efficiency aspect of CASE. The two dimensions have coefficient alpha of 0.8038 and 0.7988 respectively. The standardized item alphas are 0.8068 and 0.7984 respectively.

4.6.5 Perceived Complexity

A computation of item-to-total correlation statistics for the items measuring this construct showed that the five items 13, 14, 15, 16, and 17 (see Table 4-2, item description numbers) have item-to-total correlations of 0.8272, 0.7213, 0.8046, 0.3560, and 0.7612 respectively and a coefficient alpha of 0.8684. A plot of the these correlations in decreasing order of magnitude (see Fig. 4-2b) suggested that there was substantial drop in correlation from item 14 to 16. The plot also showed that items 13, 15, 17, and 17 form one cluster, while item 16 stands alone and was dropped.

A factor analysis of these items resulted (Table 4-3) in one simple factor explaining 78.6 percent of the total variance. The scale has a alpha coefficient of 0.9087. The standardized item alpha is 0.9085.

4.6.6 Stability of CASE Tools

A computation of item-to-total correlation statistics for the items measuring this construct showed that the five items 19, 10, 14, 1, and 15 have item-to-total correlations of 0.6961, 0.7546, 0.5445, 0.6299, and 0.4426 respectively and a coefficient alpha of 0.8188. A plot of the these correlations in decreasing order of magnitude suggested that there was no substantial drop in correlation from one item to another item. The standardized item alpha coefficient is 0.8182. A factor analysis of these items resulted in one simple factor explaining 58.6 percent of total variance.

4.6.7 Training and Human Resources Development of IS Personnel

A computation of item-to-total correlation statistics for the items measuring this construct showed that the seven items 20, 31, 34, 41, 24, 29, and 3 have item-to-total correlations of 0.6392, 0.5188, 0.7466, 0.5020, 0.4499, 0.6716, and 0.4587 respectively and a coefficient alpha of 0.8220. Although, such a high coefficient alpha does not warrant deletion of any item, a plot of these correlations in decreasing order of magnitude suggested that there was a substantial drop in correlation from item 20 to item 31, with items 34, 29, and 20 forming one cluster and items 31, 41, 24, and 3 forming another cluster, indicating that these items may not be measuring a single construct.

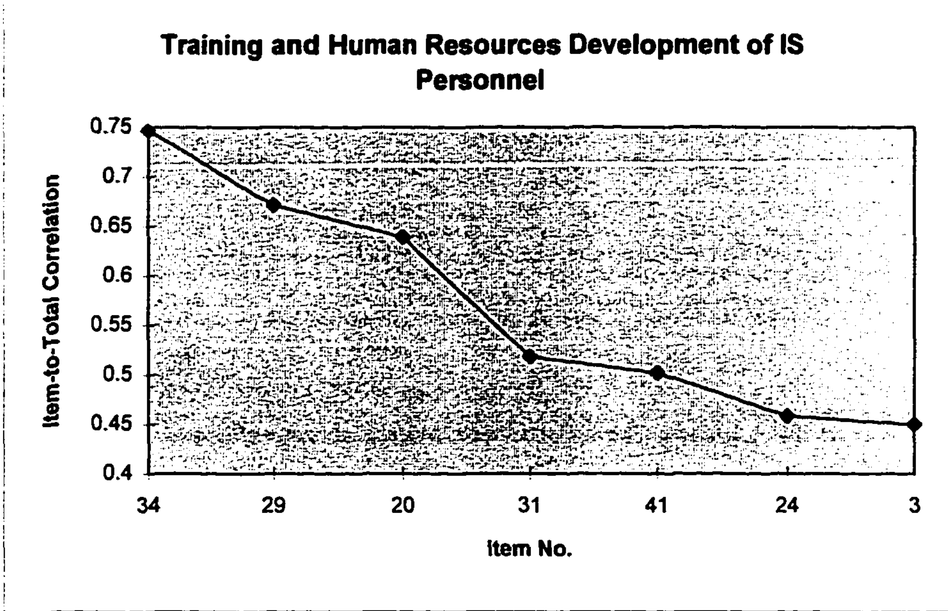
A factor analysis of these items resulted in two factors which explained 64 percent of the total variance, and confirmed the above suspicion. Item 29 was dropped as it loaded almost equally on the two factors (0.6472 and 0.4710). Item 34 was also dropped as it had a loading of 0.8119 on one factor and 0.3812 on the other factor, exceeding our selected threshold of 0.35. The remaining items were again factor analyzed and resulted (Table 4-3) in one simple factor explaining 46.5 percent of the total variance.

A computation of item-to-total correlation statistics for these items showed that the five items 20, 31, 41, 24, and 3 have item-to-total correlations of 0.6206, 0.4562, 0.5217, 0.3358, and 0.3978 respectively and a coefficient alpha of 0.7083. The standardized item alpha coefficient is 0.7040. A plot (Figure 4-2c) of these correlations in decreasing order of magnitude showed no substantial drop from one item to the other.

4.6.8 Support of Mediating Institutions

A computation of item-to-total correlation statistics for the items measuring this construct showed that the eight items 39, 32, 47, 12, 25, 2, 43, and 4 have item-to-total correlations of 0.8479, 0.8011, 0.4483, 0.7938, 0.5969, 0.3151, 0.3528, and 0.4554 respectively and a coefficient alpha of 0.8410. A plot of the these correlations in decreasing order of magnitude suggested (see Figure 4-2d) that there was a substantial drop in correlation from item 12 (0.7938) to item 25 (0.5959). Further, it showed items 39, 32, 12 forming one cluster and the remaining forming another cluster, indicating that the construct may not be unidimensional.

A factor analysis of these items resulted in two factors explaining 66.2 percent of the total variance. Item 12 was dropped as it had high loadings on the two factors (0.7220 and 0.5003). Item 39 was also dropped as it loaded 0.8449 on one factor and 0.3570 on the other factor. The remaining items were again factor analyzed and resulted (Table 4-3) in two distinct factors explaining 62.3 percent of the total variance. Items 32, 47, and 25



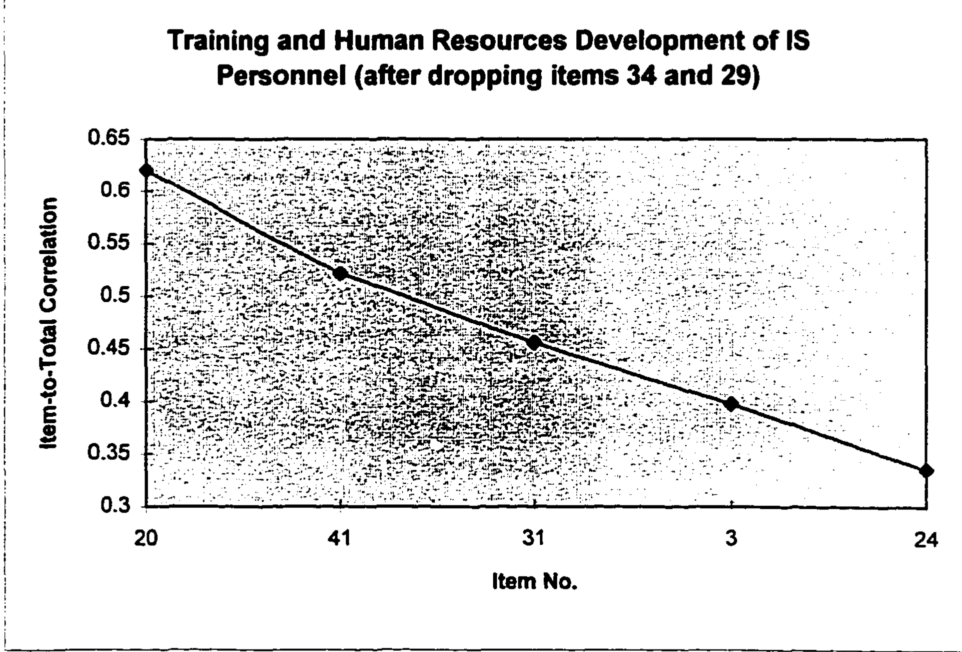
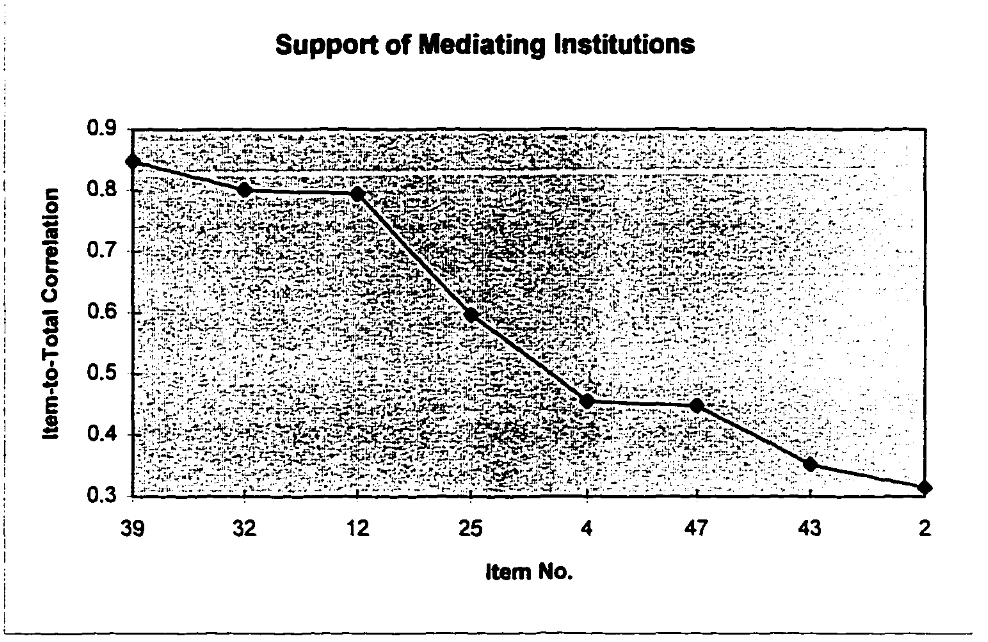


Figure 4-2c. Plot of Item-to-Total Correlations



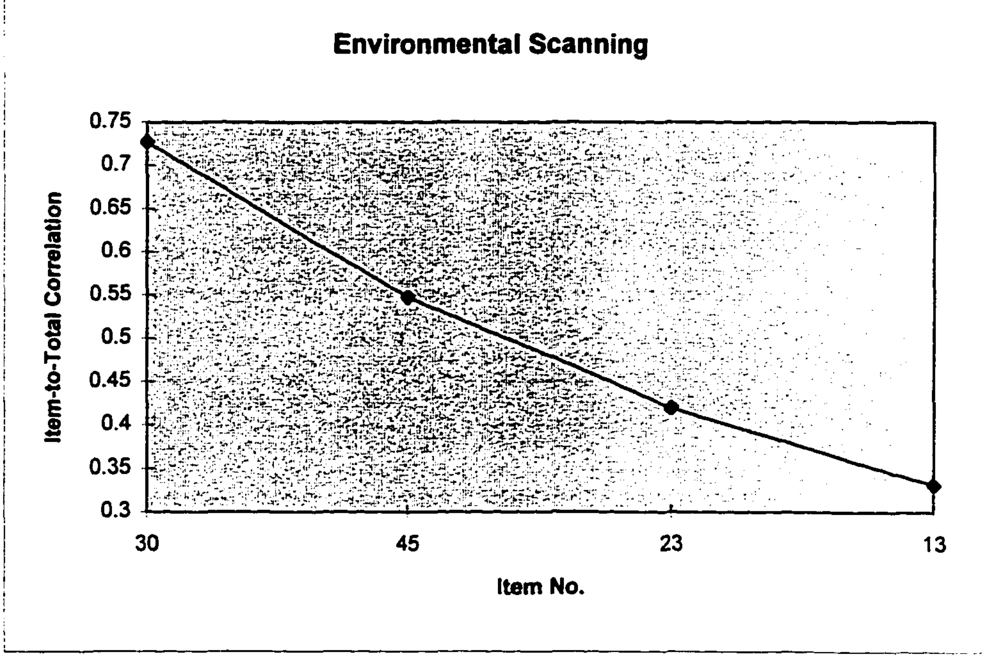


Figure 4-2d. Plot of Item-to-Total Correlations

loaded on one factor (henceforth to be called In-House Vendor Support) emphasizing the in-house support provided by vendors, while the items 2, 4, and 43 loaded on the second factor (henceforth to be called On-Line Vendor Support) emphasizing the on-line support provided by vendors.

In-house vendor support has a coefficient alpha of 0.7540 with items 32, 47, and 25 having item-to-total correlations of 0.6108, 0.5026, and 0.6416 respectively. On-line vendor support has a coefficient alpha of 0.5390 with the items 2, 43, and 4 having correlations of 0.4327, 0.3449, and 0.3259 respectively. The two factors have a standardized item alpha of 0.7542 and 0.5665 respectively.

4.6.9 Environmental Scanning

A computation of item-to-total correlation statistics for the items measuring this construct showed that the four items 29, 30, 31, and 32 have item-to-total correlations of 0.5476, 0.3318, 0.4197, and 0.7272 respectively and a coefficient alpha of 0.7067. A plot of the these correlations in decreasing order of magnitude suggested (see Fig. 4-2d) that there was no substantial drop in correlation from one item to another item. The standardized item alpha coefficient is 0.7193. A factor analysis of these items resulted in one simple factor explaining 55.4 percent of total variance (see Table 4-3).

4.6.10 Job/Role Rotation

A computation of item-to-total correlation statistics showed that both items (16, 37) had equal correlation (0.2792) with the total score. Both items were retained. The scale has an alpha coefficient of 0.4353. The standardized item alpha coefficient is 0.4365.

A factor analysis of these items resulted in one simple factor explaining 64 percent of total variance (see Table 4-3). Although the scale's reliability (Cronbach's α) of 0.4353 is much lower than that observed by Rai (1994) and is certainly a cause of concern, this construct was retained as it is deemed theoretically important.

4.6.11 Media Richness of Communication Channels

A computation of item-to-total correlation statistics for the items measuring this construct showed that the seven items 48, 26, 44, 40, 38, 7, and 22 have item-to-total correlations of 0.8058, 0.6347, 0.6314, 0.8625, 0.8081, 0.6199, and 0.6740 respectively and a coefficient alpha of 0.9043. A plot of the these correlations in decreasing order of magnitude suggested (see Fig. 4-2e) that there was substantial drop in correlation from item 48 to item 22. The plot also showed that items 40, 38, and 48 form one cluster, while items 22, 26, 44, and 7 form another cluster, indicating that the construct may not be unidimensional.

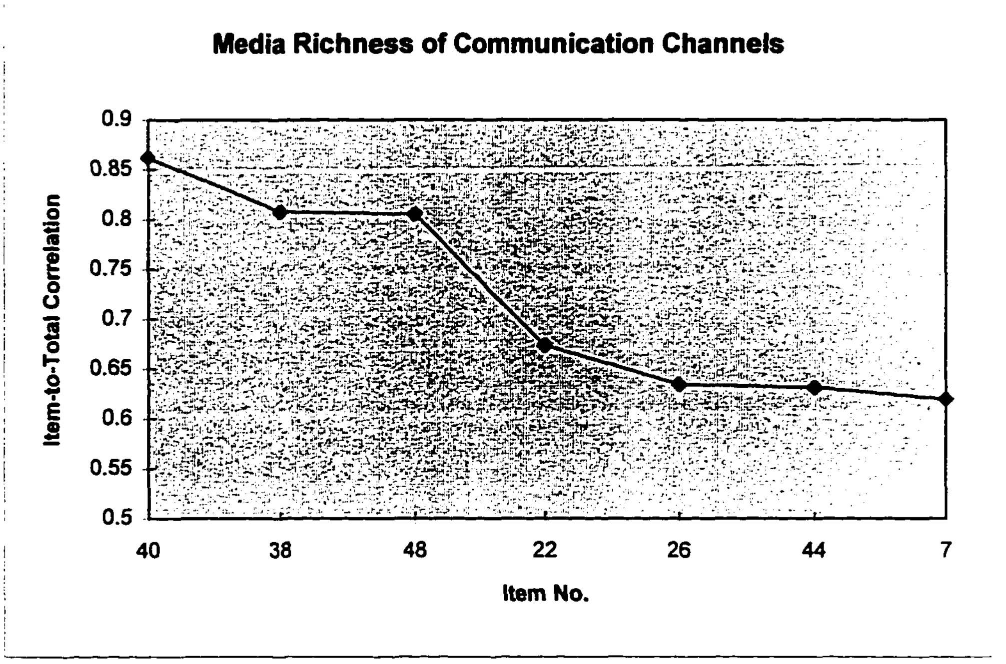
A factor analysis of these items resulted in one simple factor explaining 64.4 percent of total variance (see Table 4-3), eliminating any doubts about the unidimensionality of the construct. The scale has a standardized item alpha of 0.9059.

4.6.12 Turnover of (Managerial) IS Personnel

As indicated before, this construct was measured by a single item (9). Hence, coefficient alpha could not be calculated. It has a mean of 3.18 and a standard deviation of 1.51.

4.6.13 Turnover of (Technical) IS Personnel

A computation of item-to-total correlation statistics for the items measuring this



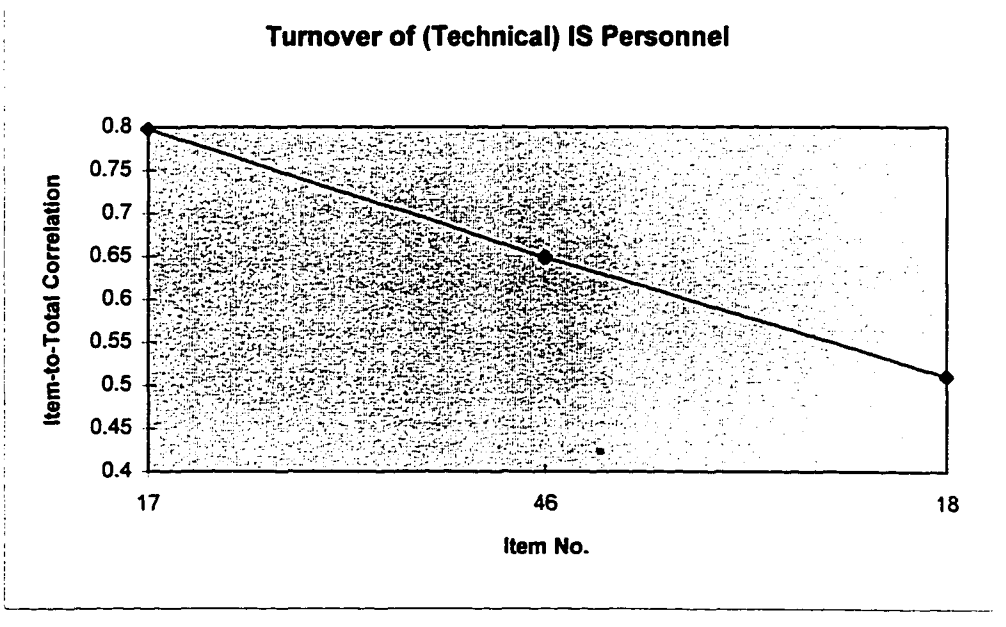


Figure 4-2e. Plot of Item-to-Total Correlations

construct showed that the three items 17, 46, and 18 have item-to-total correlations of 0.7982, 0.6488, and 0.5107 respectively and a coefficient alpha of 0.8006. A plot of the these correlations in decreasing order of magnitude (see Fig. 4-2e) suggested that there was no substantial drop in correlation from one item to another item. The standardized item alpha coefficient is 0.7982. A factor analysis of these items resulted (Table 4-3) in one simple factor accounting for 61.6 percent of the total variance, and thus confirming the unidimensionality of the construct.

Table 4-3 summarizes the operationalization of various constructs along with their alpha coefficients and factor loadings. Several heuristics have been suggested regarding acceptable levels of standardized alphas. Nunnally (1978) prescribes a value of 0.70 or higher to be acceptable in the early stages of basic research. All the constructs except prior experience of IS personnel with a compatible methodology, on-line vendor support, and job/role rotation have coefficient alphas greater than the prescribed level of 0.70. Prior experience of IS personnel with a compatible methodology, on-line support of mediating institutions, and job/role rotation have standardized alphas of 0.6219, 0.5665, and 0.4365 respectively. Prior experience of IS personnel with a compatible methodology and job/role are deemed theoretically important, and are retained for subsequent analyses. On-line support of mediating institutions is a new construct obtained from factor analysis of support of mediating institutions. It will be interesting to see what kind of relationship it has with adoption and infusion, and hence this construct is also retained. However, any results pertaining to these constructs should be interpreted with caution.

4.7 Validity

Validity is the degree to which an instrument measures the construct under investigation (Kerlinger, 1986). Cronbach (1971) describes validation as the process by which a test developer or test user collects evidence to support the types of inferences that are to be drawn from test scores. There are two major types of validity -- content validity and construct validity.

4.7.1 Content Validity

Content validity is the representativeness or sampling adequacy of the content of a measuring instrument (Kerlinger, 1986). An instrument valid in content is one that has drawn representative questions from a universal pool (Cronbach, 1971; Kerlinger, 1986). With representative content, the instrument is more expressive of the true mean than one that has idiosyncratic questions from the set of all possible items (Straub, 1989). A content-valid instrument is difficult to create and even more difficult to verify because of the universe of possible content is virtually infinite. Cronbach (1971) suggests a review process whereby experts in the field familiar with the content universe evaluate versions of the instrument again and again until a form of consensus is reached.

The content validity was established through the extreme care taken in the selection of items that measure the constructs and subjecting them to two stages of pilot-testing. The items used for measuring different constructs were determined after a careful review of relevant literature, thus drawing representative questions from a universal pool. After, developing items for different constructs, the instrument was validated in two stages as described earlier (see section 4.5.3).

4.7.2 Construct Validity

Construct validity is an operational issue. It asks whether the measures chosen are true constructs describing the event or merely artifacts of the methodology itself (Campbell and Fiske, 1959; Cronbach, 1971). If constructs are valid in this sense, one can expect relatively high correlations between measures of the same construct using different methods (convergent validity) and low correlations between measures of constructs that are expected to differ (discriminant validity) (Campbell and Fiske, 1959). The construct validity of an instrument can be assessed through multi-trait-multi-method (MTMM) techniques (Campbell and Fiske, 1959) or techniques such as confirmatory or principal component factor analysis (Kerlinger, 1986; Nunnally, 1978).

Kerlinger and Kaya (1970) recommend a two-step process to test construct validity of an instrument. In the first step, the convergent validity of each construct needs to be evaluated by principal component analysis of the items of only that construct. This removes outliers and identifies subdimensions (if any) for the constructs. Subsequently, in the second step, discriminant validity needs to be evaluated by subjecting all the items measuring the various constructs to principal component analysis to determine if the items load on the appropriate constructs.

Following these guidelines, the psychometric properties of the instrument were evaluated using principal component factor analysis. Details of factor analysis are described in the previous section on reliability. Table 4-3 shows a summary of the results of the convergent validity testing.

An analysis of the results show that all the constructs except support of mediating institutions, and perceived relative advantage exhibit sufficient convergent validity. The eight items measuring support of mediating items split into two separate factors measuring in-house and on-line support provided by vendors. The twelve items measuring relative advantage split into two factors measuring the capability and efficiency aspects of CASE tools. All these factors are treated as separate constructs in subsequent analyses.

Discriminant validity could not be assessed by subjecting all the remaining items after purification (in section 4.6) to principal component analysis because of relatively small sample size. Tabachnick and Fidell (1989) recommend at least five cases for each observed variable. Although, this requirement was met in assessing convergent validity, it could not be met in assessing discriminant validity as the total number of items entering factor analysis after elimination of "garbage items" is 40.

To check discriminant validity, a correlation analysis was performed among all the variables under each group in the research model except the ones under information distribution, information interpretation, and organizational memory factors which were pooled together. The results of this analysis are shown in Table 4-4.

The results indicate that most of the variables exhibit sufficient discriminant validity, though there remains a concern about training and human resources development of IS personnel, environmental scanning, job/role rotation, media richness of communication channels, turnover of (managerial) IS personnel, and turnover of (technical) IS personnel. Training and human resources development of IS personnel and environmental scanning are conceived as theoretically different constructs. Similarly,

Table 4-4. Discriminant Validity of Independent Variables*

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Prior experience of IS personnel	1.000														
2. Career orientation compatibility of IS personnel	.0785	1.000													
3. Multiskilled IS personnel	-.2112	.0324	1.000												
4. Perceived capability				1.000											
5. Perceived efficiency				.2184	1.000										
6. Perceived complexity				-.1348	-.1334	1.000									
7. Stability of CASE toolset				-.2082	.0705	-.1094	1.000								
8. Training and human resources development								1.000							
9. In-house vendor support								.1125	1.000						
10. On-line vendor support								.0385	.3103	1.000					
11. Environment scanning								.6924 (.000)	.1367	.0646	1.000				
12. Job/role rotation												1.000			
13. Media richness of commmunication channels												.4784 (.001)	1.000		
14. Turnover of (managerial) IS personnel												.0214	.2110	1.000	
15. Turnover of (technical) IS personnel												.1655	.1548	.7608 (.000)	1.000

*Numbers in parentheses show two-tailed p-values. Insignificant p-values are not shown.

job/role rotation and media richness of communication channels are conceived as different theoretical constructs. Hence, they are kept as separate constructs despite high correlation between these pairs. On-line vendor support is a new construct obtained from factor analysis, and is also kept as a separate construct.

The next chapter describes data analysis procedures used to identify relationship between different dependent and independent variables.

CHAPTER V
DATA ANALYSES AND DISCUSSIONS

This chapter describes the details of statistical procedures used to analyze data and discusses the results of data analyses. Following a description of data cleaning process, it describes the demographic profile of the respondents. It then discusses the difference between different groups of organizations -- "adopters", "considered", and "non-considered" of CASE using two statistical techniques -- multivariate analysis of variance and discriminant function analysis. Finally, it identifies significant relationships between dependent and independent variables using robust regression.

5.1 Coding of Survey Data

Usable responses obtained from respondents were coded for statistical analyses. The following coding relates to the questions in part I of the questionnaire. Organizational unit was coded on a nominal scale of 1 to 4 (1 = corporate, 2 = division, 3 = business unit, 4 = other). Industry type was coded on a nominal scale of B to O (B = commercial banking, D = diversified finance, F = federal government, H = health service, I = insurance, L = local government, M = manufacturing, R = retail, S = state government, T = transportation, U = utilities, and O = others). Organizational size was coded in millions of dollars. Size of information systems department (or ISD size represented by the number of full-time employees in the ISD), number of active projects in the ISD, and proportion of development projects in the ISD, number of years in the position, and when CASE tools were evaluated were coded as numbers as provided by the respondents. Job title was coded on a nominal scale of 1 to 8 (1 = director of IT, 2 = MIS manager, 3 = vice-president, 4 = IS supervisor, 5 = IT analyst, 6 = chief information officer, 7 = chief executive officer, 8 = others). CASE tools considered and CASE tools used were coded on a nominal scale of 1 to 4 (1 = full life-cycle, 2 = front-end, 3 = back-end, 4 = other). If a respondent responded with more than one alternatives, for example both 1 and 2, it was coded as a combination of those alternatives, such as 12.

Responses of all the questions in the part II and part IV of the questionnaire were coded as numbers encircled by the respondents on the returned questionnaires. Some respondents did not encircle any number but showed their responses by a check-mark between numbers on the scale. These responses were coded again as numbers using best estimation of their position on the scale. Questions 4, 6, 14, 16, and 36 in the part IV of the questionnaire were reverse coded as these items had been negatively worded to reduce method bias (see Chapter IV).

Responses to the CASE usage matrix in the part III of the questionnaire were coded on an interval scale of 0 to 4 (0 = not used at all, 1 = used on an experimental basis (or in pilot projects), 3 = used on regular basis by a few people/projects, 4 = used on regular basis by most people/projects, 4 = used on regular basis by all people/projects).

5.2 Cleaning of Data

After responses were coded, data was cleaned using the guidelines provided by Tabachnick and Fidell (1989) (see Table 5-1).

Table 5-1. Checklist for Screening Data

1. Inspect univariate descriptive statistics for accuracy of input (a) Out-of-range values (b) Plausible means and descriptions (c) Coefficient of variation
2. Evaluate number and distribution of missing data; deal with problem
3. Identify and deal with outliers (a) Univariate outliers (b) Multivariate outliers
4. Identify and deal with skewness (a) Locate skewed variables (b) Transform them (if desirable) (c) Check result of transformation
5. Identify and deal with nonlinearity and heteroscedasticity
6. Evaluate variables for multicollinearity and singularity

5.2.1 Accuracy of Input

Univariate descriptive statistics for all the questions in the questionnaire were computed to find any out-of-range values, implausible means, and standard deviations. An inspection of these statistics showed out-of-range values for two cases. The values of these cases were corrected after cross-checking with the corresponding respondents' responses. Minimum values, maximum values, ranges, means, and variances of all other questions seemed plausible.

5.2.2 Missing Data

There were many missing values, mostly on organizational size, ISD size, and number of active projects in ISD. Respondents were asked to indicate the size of their organization in terms of annual sales turnover. Some respondents did not respond to this question because of privacy reasons. Others, who belonged to education, government, finance, banking, and insurance sectors, did not have an annual sales figure to report. In place of providing sales turnover, education and government sector respondents provided with annual budget, while finance, banking, and insurance sector respondents provided with annual asset figures. Although, assets and budgets figures were recorded for these cases in the data file, annual sales turnover for these respondents were left as missing values. A majority of respondents provided data on ISD size and number of active projects in their ISD (337 and 318 respectively out of a total of 350). Some respondents indicated confusion with the term "projects" when indicating number of active projects in their ISD. Since all these variables pertain to respondents' demographic profile, missing values for these variables are not seen as a major concern, and were left as they were.

Missing values for other variables were dealt with following one of many suggestions provided by Tabachnick and Fidell (1989): all the available pairs of values were used (corresponding to pairwise deletion in the SPSS package) when calculating correlation matrix for different statistical analyses.

5.2.3 Outliers

Outliers are cases with such extreme values on one or a combination of variables that they unduly influence the size of correlation coefficients, the average value for a group, or the variability of scores within a group. With respect to the correlation coefficient, outliers are influential because of their power to determine which one of a number of possible regression lines is chosen. Cases can be extreme with respect to one variable (univariate outliers) or two or more variables in combination (multivariate outliers).

Univariate outliers were identified by computing standardized (z) scores for each item in the questionnaire. A cut-off of $z = \pm 3.00$ was used to identify outliers. A close inspection of the standardized scores showed that there were 2 outliers for organizational size, 6 for ISD size, 8 for "number of active projects in the ISD", 5 for "years in the position", and 1 for "when CASE tools were evaluated". In the part II of the questionnaire one and the same case was found to be an outlier on questions 2 ($z = -3.6447$) and one on question 10 ($z = -3.1735$) on the variable perceived capability. In part III of the questionnaire, two cases were found to be univariate outliers on CASE functionalities 6 ($z = 3.0816$) and 8 ($z = 3.5386$), and 14 ($z = 3.1869$). No case was found to be a univariate outlier for any variable in the part IV of the questionnaire. A close examination of the outlying cases showed no discernible pattern.

If a variable is approximately normally distributed, z-tables can be used to calculate the expected percentage of cases with standardized scores over 3.00 for a given sample size (Tabachnick and Fidell, 1989) . The expected number of cases with standardized scores over 3.00 for sample sizes of 350 (total), 105 (considered), and 46 (adopters) are 0.91 (= 2x(0.5-0.4987)x350), 0.27, and 0.12 respectively. Since, there are more outliers in the data set than expected, it is critical that outliers be carefully dealt with.

Input data for these outlying cases were again checked to ensure that data entered was correct for these cases. It was found that if scores of variables organizational size, ISD size, number of active projects in the ISD, and number of years in the position were log transformed, the problem of outliers could be resolved (Tabachnick and Fidell, 1989). High skewness (discussed in the next section) of the distribution of the scores of these variables further indicated that they need to be log transformed. Since scores on the item "when CASE tools were evaluated" showed just one outlier with a z-value of 3.6279, it was retained, however, changing its value on the outlying case to a z-value equal to 3.00, as suggested by Tabachnick and Fidell (1989). The outlying cases in part II and III of the questionnaire were also retained by changing corresponding raw scores equivalent to standardized z-scores of 3.00. This treatment of the outliers preserves the deviancy of the outlying cases without allowing them to be so deviant that perturbs correlation.

Multivariate outliers were found by performing regression analysis (SPSS REGRESSION) of independent or predictor variables with the dependent or grouping variable of interest for MANOVA and discriminant function analysis and plotting cases beyond ±3 standard deviations with CASEWISE option. Three cases were found to be outliers for both MANOVA and discriminant function analyses. These cases were excluded from these analyses. Multivariate outliers were not expected to pose much problem in identifying significant relationship between independent and dependent variables as robust regression analysis was used for this purpose. It uses a function of residuals to identify multivariate outliers and weighs them less than other cases, thus reducing the influence of outlying cases.

5.2.4 Skewness

Assumptions of normality, linearity, and homoscedasticity underlie most of the statistical analyses. Skewness of a distribution is its deviation from normality. It may cause distortion of Type I error and stability in estimates of regression coefficients for variables (Fleming and Pinneau, 1980).

Table 5-2 shows the z-value of skewness for variables whose sampling distribution exhibited a high deviation from normality. As can be seen all the variables are demographic in nature, and all but one have very high positive z-values of skewness indicating severe positive skewness. As discussed in the last section, there were outliers on these same variables which probably skewed their distributions. Tabachnick and Fidell (1989) recommend a logarithmic transformation for such variables. These variables were log transformed accordingly. Subsequent calculation of their descriptive statistics showed that logarithmic transformation was successful in eliminating skewness.

Table 5-2. Skewness of Distributions

Variables	Mean	S.E. Mean	Std. Dev.	Skewness	S.E. Skewness	z-Value
Organization Size ($M)	789.87	146.05	2156.42	6.048	0.165	36.655
ISD Size	60.84	7.01	128.72	4.485	0.133	33.722
No. of Active ISD Projects	31.27	3.79	67.5	5.358	0.137	39.109
No. of Years in Job	7.58	0.35	6.37	1.497	0.132	11.341
CASE Tools First Evaluated (years ago)	4.63	0.23	2.31	0.945	0.236	4.004

5.2.5 Nonlinearity and Heteroscedasticity

The assumption of linearity requires that the relationship between two variables can be described using a straight line (Tabachnick and Fidell, 1989). Linearity is important to multivariate statistics as the correlation coefficient, which forms the basis for most multivariate calculations, is sensitive only to the linear component of the relationship between two variables. Bivariate scatterplots for different variables were examined to detect departures from normality.

The assumption of homoscedasticity requires that the variability in scores on one variable is roughly the same at all values of the other variable (Tabachnick and Fidell, 1989). It is related to the assumption of normality. When heteroscedasticity is present, the relationship between the variables is not captured totally by the correlation coefficient. Transformation of skewed variables identified earlier helped eliminate heteroscedasticity and ensure normality.

5.2.6 Multicollinearity and Singularity

Multicollinearity occurs when two variables in a correlation matrix are perfectly (or nearly perfectly) correlated and when they show similar pattern of correlations with the other variables (Tabachnick and Fidell, 1989). Singularity occurs when score on a variable is a linear (or nearly linear) combination of scores on other variables. They cause problems in multivariate analyses by rendering matrix inversion unstable. A high Pearson correlation between two variables is an indication of bivariate collinearity. However, sometimes the problem involves a combination of several variables instead of just two. In such cases, high squared multiple correlations or low tolerance between one variable and a combination of others is an indication of multicollinearity. To investigate multicollinearity and singularity, multiple regression can be performed, with each variable in turn serving as a dependent variable and all others as independent variables. If some combination of independent variables has a high squared multiple correlation with one of the dependent variables, those independent variables are multicollinear or singular.

Once multicollinearity or singularity is detected, there are several methods to deal with it. Perhaps the simplest and best is to delete the offending variable(s) (Tabachnick and Fidell, 1989). Because one variable is a combination of others, information is not lost by deleting it. One needs to consider the ease of interpreting variables, their relevance to other work, their cost, etc., in order to select variables for deletion. A second method involves subjecting the variables to principal components analysis and then using the scores on components as the variables in the subsequent analyses. A third solution is to use stepwise, or hierarchical entry of variables into the analysis so that only one or a few of the variables that are multicollinear are used. We used the third method to address multicollinear problems.

5.3 Demographic Profile of Respondents

Table 5-3 shows distribution of responses by organizational unit to which IS department provided its services. More than half of the organizational units which received IS services was corporate (65.2 percent). Division constituted about 19 percent of all the organizational units served, while the business unit accounted for about 7 percent.

Table 5-3. Distribution of Responses By Organizational Unit

Organizational Unit	Frequency	Percent
Corporate	229	65.4
Division	65	18.6
Business Unit	24	6.9
Others	27	7.7
Missing	5	1.4
Total	350	100

Table 5-4. Distribution of Organizations By Industry

Industry	Frequency	Percent
Commercial Banking (B)	7	2
Diversified Finance (D)	7	2
Education (E)	44	12.6
Federal Government (F)	7	2
Health Service (H)	16	4.6
Insurance (I)	18	5.1
Local Government (L)	10	2.9
Manufacturing (M)	182	52
Other (O)	5	1.4
Retail (R)	16	4.6
State Government (S)	19	5.4
Transportation (T)	5	1.4
Utilities (U)	14	4
Total	350	100

Table 5-5. Distribution of Organizations By Industry (Consolidated)

Sector	Frequency (Responses)	Percent
Manufacturing	182	52
Government	36	10.3
Service	132	37.7
Total	350	100

Table 5-4 shows distribution of responses by industry. It can be seen that almost half of respondents were from the manufacturing sector, in all 51.4 percent, while education was the second highest sector with 12.6 percent. Local, state and federal government sectors together accounted for 8.8 percent of the total response, while insurance accounted for 5.1 percent.

Table 5-5 shows distribution of responses by industry when different industry sectors were consolidated into three categories -- manufacturing, government, and service.

Table 5-6a shows distribution of responses by the size of the organization, while Table 5-6b shows the distribution of organizations by industry and size. Twenty-six percent of the organizations had annual sales revenue of less than 100 million dollars. The organizations with sales revenue between 100 and 500 million dollar and those with more than 500 million dollars accounted for 20.9 and 15.4 percent respectively of the total response. Most of the organizations in all the three size categories belonged to manufacturing sector (Table 5-6b).

Based on CASE tools usage, a distinction is made here among different organizations for subsequent analyses. The organizations which reported using used CASE tools for systems development are categorized as "adopters"; the organizations which considered using CASE tools and evaluated them for that purpose, but did not use them are categorized as "considered". The organizations which did not consider using CASE tools are categorized as "not considered". There were 46 "adopters", 59 "considered", and 245 "not considered" organizations. "Considered" and "not

Table 5-6a. Distribution of Organizations By Size (Sales Revenue)

Sales Revenue (million dollars)	Frequency	Percent
<100	91	26.0
>100 - <500	73	20.9
>500	54	15.4
Missing	132	37.7
Total	350	100.0

Table 5-6b. Distribution of Organizations By Industry and Size (Sales Revenue)

	Sales Revenue (million dollars)		
Industry	<100	101-500	>500
Diversified Finance (D)	0	1	2
Health Service (H)	3	5	3
Insurance (I)	4	4	5
Manufacturing (M)	73	49	34
Other (O)	3	0	0
Retail (R)	2	8	6
Transportation (T)	0	3	2
Utilities (U)	6	3	2
Total	91	73	54

considered" groups together are also categorized as "non-adopters" as these organizations did not use CASE for systems development work. For some analyses when comparing "considered" and "not considered" groups, a sample size of 105 (59 originally considered and 46 adopters) is used for "considered" group. It can be argued that "adopters" first belonged to "considered" group and became "adopters" later. Whenever this bigger sample size has been used, it is indicated there.

Table 5-7a shows the distribution of organizations by the CASE tools considered. More than half of the organizations considered a full life-cycle CASE tool, probably because of their ability to address all phases of systems development. About 15 percent considered front-end tools, while 7 percent considered back-end tools. Interestingly, about 20 percent organizations considered using a combination of full life-cycle, front-end, and back-end tools, probably because of strength of phase specific tools to address the phase specific problems. Table 5-7a also shows the time elapsed since CASE tools were evaluated first. On average, organizations had evaluated CASE tools 4.6 years ago.

Table 5-7b shows the distribution of organizations by their use of CASE tools. It also shows a contrast between what CASE tools they evaluated and what they adopted. It is worth noting that although 59 percent of the organizations considered using full life-cycle tools, only 39 percent adopted them. On the other hand, while only 20 percent considered using front-end tools, 35 percent adopted them. The percent of organizations which used a combination of tools was 18 percent, almost the same as that of the organizations which considered them.

Table 5-8 shows the distribution of organizations by their ISD size, that is number

Table 5-7a. Distribution of Organizations By CASE Tools Considered (N=105)

Scope of CASE Tools	Frequency	Percent	When First Evaluated (yrs. ago)
Full life-cycle	57	54.3	4.3
Full-life cycle, Front-end	7	6.7	6.9
Full life-cycle, Front-end, Back-end	9	8.6	5.6
Full life-cycle, Front-end, Back-end, Other	2	1.9	5.5
Front-end	16	15.2	4.3
Back-end	7	6.7	5.5
Front-end, Back-end	3	2.9	4.8
Other	1	0.95	1.0
Missing	3	2.86	
Total	105	100	4.6 (overall avg.)

Table 5-7b. Distribution of Organizations By CASE Tools Usage (N=46)

	Considered		Adopted	
Scope of CASE Tools	Frequency	Percent	Frequency	Percent
Full life-cycle	27	58.7	18	39.1
Full life-cycle, Front-end	1	2.2	0	0
Full life-cycle, Front-end, Back-end	6	13.0	5	10.9
Full life-cycle, Other	0	0	1	2.2
Front-end	9	19.6	16	34.8
Back-end	2	4.3	3	6.5
Front-end, Back-end	1	2.2	3	6.5
Total	46	100	46	100

Table 5-8. Distribution of Organizations By ISD Size

ISD Size	Frequency	Percent
1-10	138	39.4
11-50	115	32.9
51-100	32	9.1
>100	52	14.9
Missing	13	3.7
Total	350	100.0

Table 5-9. Distribution of Organizations By Number of Active Projects

No. Of Active Projects	Frequency	Percent	Percent of Development Projects in ISD	Percent of Maintenance/ Enhancement Projects in ISD
1-10	150	42.9	42.22	57.70
11-50	125	35.7	39.90	58.91
51-100	16	4.6	25.31	74.69
>100	27	7.7	27.92	67.21
Missing	32	9.1		
Total	350	100.0	39.35 (overall average)	59.77 (overall average)

of employees in their information systems department. About 60 percent of organizations had ISD employees between 1 and 50, with 39 percent having ISD employees between 1 and 10. Organizations with ISD employees between 51 and 100 and those having more than 100 accounted for 9 and 15 percent of the total response.

Table 5-9 shows distribution of organizations by number of active projects in their ISD. About three-fourth of organizations had a number of active projects ranging between 1 and 50 at the time the survey was administered, with about 43 percent having a number of projects between 1 and 10. The organizations which had more than 100 active projects accounted for 8 percent of the total response. For these organizations, the proportion of development and maintenance/enhancements projects accounted for 39.35 percent and 59.77* percent respectively.

Table 5-10 shows the distribution of respondents by their job title. A majority of respondents were either director of the information technology (36.3 percent) or MIS manager (33.1 percent). Around 13 percent were vice-presidents. IS supervisor, IT analysts, chief information officer, chief executive officer, and others accounted for 28 percent of the response. Table 5-10 also shows the average number of years the respondents were in that position. Respondents who were vice-presidents were in that position for longest time (8.1 years on average), whereas respondents who were chief information officers were in that position for shortest time (3.4 years on average).

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*These percentages do not add up to 100 because of rounding errors.

Table 5-10. Response By Respondent's Job Title

Job Title	No. of Responses	Percent	Avg. Years In This Position
Director of IT	127	36.3	7.7
MIS Manager	116	33.1	7.7
Vice-President	46	13.1	8.1
IS Supervisor	10	2.9	6.4
IT Analyst	7	2.0	6.8
Chief Information Officer	6	1.7	3.4
Chief Executive Officer	5	1.4	8.2
Others*	24	6.9	6.9
Missing	9	2.6	
Total	350	100.0	7.6 (overall avg.)

*Others include Chief Financial Officer, President, IS Coordinator, Dean, etc.

5.4 Response Bias

Table 5-11a shows the results of a chi-square test for response bias. The result is significant at 0.05 level of significance ($p < 0.05$), indicating that there was a response bias among respondents from different industries. There were more responses from education and state government sectors than expected, while there were fewer responses from federal government and manufacturing sectors. However, if the industry sectors are consolidated in manufacturing, government, and service categories, the result is not significant (see Table 5-11b). This indicates that consolidation offsets the higher response from one sector with the lower response from another sector.

5.5 Measurement of Independent and Dependent Variables

The operationalization of the independent and dependent variables has been discussed in Chapter IV. Table 5-12 shows some descriptive statistics for various variables.

5.6 Modification of Hypotheses

Reliability and validity analyses (see Chapter IV) suggested that support of mediating institutions and perceived relative advantage are not unidimensional constructs, each having two distinct dimensions. Each of these dimensions is treated as a separate construct for all the analyses in this chapter. Thus support of mediating institutions is split into in-house vendor support and on-line vendor support, while perceived relative advantage is split into perceived capability and perceived efficiency of

Table 5-11a. Results of Chi-Square Test

Industry Sectors	Cases			Residual
	Observed	Percent in Database	Expected	
Commercial Banking (B)	7	3.2	11	-4
Diversified Finance (D)	7	2.5	9	-2
Education (E)	44	8.5	30	14
Federal Government (F)	7	4.0	14	-7
Health Service (H)	16	5.0	17	-1
Insurance (I)	18	4.9	17	1
Local Government (L)	10	3.9	14	-4
Manufacturing (M)	182	54.4	190	-8
Other (O)	5	1.1	4	1
Retail (R)	16	5.3	18	-2
State Government (S)	19	3.1	11	8
Transportation (T)	5	1.3	5	0
Utilities (U)	14	2.8	10	4
Total	350	100	350	

Ci-Square	D.F.	Significance
21.4201	12	.0446

Table 5-11b. Results of Chi-Square Test
(industry sectors consolidated)

Industry Sector	Cases			Residual
	Observed	Percent in Database	Expected	
Manufacturing	182	54.36	190	-8.00
Government	36	11.00	39	-3.00
Service	132	34.64	121	11.00
Total	350	100	350	

Chi-Square	D.F.	Significance
1.5676	2	0.4567

Table 5-12. Dependent and Independent Variables

Variables	Range of Possible Scores	Lowest Score	Highest Score	Mean	Standard Deviation
Adoption	0-1	0.042	1.000	0.646	0.219
Infusion	0-1	0.010	0.848	0.349	0.180
Prior Experience of IS Personnel With a Compatible Methodology	2-14	2	13	5.826	2.652
Career Orientation of IS Personnel	2-14	2	14	7.500	2.563
Multiskilled IS Personnel	4-28	12	28	23.391	3.207
Capability*	3-21	4	21	15.655	3.194
Efficiency	3-21	6	21	13.810	3.519
Perceived Complexity	4-28	4	28	16.152	5.383
Stability of CASE Tools	4-28	4	28	15.196	5.726
Training and Human Resources Development of IS Personnel	5-35	7	28	18.652	5.043
In-House Vendor Support	2-14	2	14	9.174	3.086
On-Line Vendor Support	3-21	3	20	14.478	3.740
Environmental Scanning	3-21	4	19	11.717	4.070
Job/Role Rotation	2-14	3	14	7.652	2.505
Media Richness of Communication Channels	7-49	5**	49	22.217	9.966
Turnover of (Managerial) IS Personnel	1-7	1	7	3.178	1.512
Turnover of (Technical) IS Personnel	3-21	3	16	9.889	3.706

*N used for perceived capability, perceived efficiency, and perceived complexity is 105. For other variables N = 46.

**This value of 5 is due to missing values on two items used in calculation of the variable media richness of communication channels on one case.

CASE technology. Below, the corresponding hypotheses in Chapter III are modified to reflect the above changes.

H11a-11b: Perceived capability of CASE technology will be positively related to adoption and infusion of CASE.

H12a-12b: Perceived efficiency of CASE technology will be positively related to adoption and infusion of CASE.

H19a: In-house vendor support will be positively related to adoption of CASE technology.

H19b: In-house vendor support will not be related to infusion of CASE technology.

H20a: On-line vendor support will be positively related to adoption of CASE technology.

H20b: On-line vendor support will not be related to infusion of CASE technology.

Table 5-13 shows the revised hypothesized relationships between different independent and dependent variables.

5.7 Profiles of "Adopters", "Considered", and "Not Considered"

Multivariate analysis of variance (MANOVA) and discriminant function analyses were performed to find out whether "adopters", "considered", and "not considered" groups significantly differed on organizational size, ISD size, number of active projects, proportion of development projects, and capability, efficiency, and complexity of CASE tools. Capability, efficiency, and complexity of CASE tools were only used in the analysis of the groups involving "adopters" and "considered" as data on these variables

Table 5-13. Revised Hypothesized Relationships Between Independent and Dependent Variables

Independent Variables	Hypothesized Relationship with Dependent Variables		Related Hypotheses
	Adoption	Infusion	
Prior experience of IS professionals	Positive	Positive	Hypotheses 1-2
Career orientation compatibility of IS professionals	Positive	Positive	Hypotheses 3-4
Multiskilled IS personnel	Not Related	Positive	Hypotheses 9-10
Perceived capability	Positive	Positive	Hypotheses 11a-11b
Perceived efficiency	Positive	Positive	Hypotheses 12a-12b
Perceived complexity	Negative	Negative	Hypotheses 13-14
Stability of CASE toolset	Positive	Not Related	Hypotheses 15-16
Training and human resources development	Positive	Positive	Hypotheses 17-18
In-house vendor support	Positive	Not Related	Hypotheses 19a-19b
On-line vendor support	Positive	Not Related	Hypotheses 20a-20b
Environment scanning	Positive	Positive	Hypotheses 21-22
Job/role rotation	Positive	Positive	Hypotheses 23-24
Media richness of communication channels	Positive	Positive	Hypotheses 25-26
Turnover of (managerial) IS Personnel	Negative	Negative	Hypotheses 5-6
Turnover of (technical) IS Personnel	Positive	Positive	Hypotheses 7-8

were collected for only these groups. MANOVA was performed to examine the combined role of these variables in differentiating one group from another. Stepdown MANOVA was used to identify variables which uniquely contributed to the differentiation among the three groups. Discriminant functional analyses were done to identify unique combination of variables which maximally differentiated the group membership for different cases.

5.7.1 Multivariate Analysis of Variance (MANOVA)

When predictor variables are correlated, they can be seen as measuring overlapping aspects of the same behavior. A problem with reporting univariate F's in such case is that of inflation of Type I error rate. With correlated predictor variables the univariate F's are not independent, and no straight forward adjustment of the error rate is possible. An advantage of MANOVA over a series of ANOVAs, one for each predictor variable, is in protection against Type I error. However, this advantage is seen only when a two-tailed significance test is appropriate. If a one-tailed test is desired, use of MANOVA may result in an unacceptable loss of power. A correlation analysis showed that organizational size, ISD size, and number of active projects are highly correlated (see Table 5-14). Also, since the purpose here was to determine if there was any difference between the group means, a two-tailed test was desired. MANOVA was therefore deemed appropriate.

The problems of inflated Type I error rate and the nonindependence of univariate F tests can be further addressed by the procedures of stepdown analysis in MANOVA (Tabachnick and Fidell, 1989). This procedure calls for a determination of priority of

Table 5-14. Correlation Matrix

Variables	1	2	3	4	5	6	7
1. Organizational size	1.000						
2. ISD Size	0.6218	1.000					
3. No. of active projects in ISD	0.3012	0.4638	1.000				
4. Proportion of development projects	0.1534	0.0732	-0.1026	1.000			
5. Capability	-0.0170	0,0262	-0.0630	-0.0852	1.000		
6. Efficiency	-0.0368	-0.2050	-0.1748	-0.1214	0.3042	1.000	
7. Complexity	0.1137	0.0279	0.0921	-0.0114	-0.3141	-0.3243	1.000

predictor variables in terms of theoretical or practical interest. The predictor variables are then tested in a series of ANCOVAs (analysis of covariance). The "most important" predictor variable is tested first, with appropriate adjustment of alpha, in a univariate ANOVA. Each successive predictor variable is then tested with higher-priority predictor variable covariates, to see if the new variable significantly adds to the combination of variables already tested.

5.7.1.1 "Adopters", "Considered", and "Not Considered"

Since multivariate model that underlies MANOVA (and other multivariate techniques) is based on the multivariate normal distribution, multivariate normality was assured by having more than 25 cases in each cell of 1x3 (adopter, considered, and not considered) design. This produces more than 20 df for error in the smallest group (adopter) which is suggested (Tabachnick and Fidell, 1989) for robustness of the multivariate normality test, even with unequal sample sizes in the three cells. Since MANOVA is very sensitive to outliers, three (univariate) outlying cases on the variable perceived capability were excluded from the analysis. SPSS REGRESSION analysis of all the predictor variables with the grouping variable was done with CASEWISE PLOT option to identify multivariate outliers. No multivariate outliers was found. MANOVA also requires homogeneity of variance-covariance matrices. If sample sizes are equal, robustness of significance tests is expected regardless of the outcome of Box's M test. However, if sample sizes are unequal and Box's M test leads to rejection of the assumption of homogeneity of variance-covariance matrices at $p < 0.001$, then robustness is not guaranteed. A test for homogeneity of covariance matrices performed through

SPSS MANOVA produced F (20, 18251) = 31.90, $p > 0.05$ for Box's M, indicating that there was no statistically significant deviation from homogeneity of covariance matrices. Scatterplots between different predictor variables (see for example, Fig. 5-1 for the plot between organizational size of and ISD size) were examined for linearity through SPSS SCATTERPLOT. None of the scatterplots showed gross deviation from normality, and since minor violations of the assumption of linearity should do nothing except reduce the power of the MANOVA, it was decided to retain all the variables. Bartlett's test of sphericity (144.37) with 6 d.f. was found significant at $p < 0.001$, and hence multicollinearity and singularity were also judged not to be a problem.

Three parallel tests of significance are shown in Table 5-15a. All tests show significant effects. Using Wilks' Lambda as a criterion (0.8569), the combined predictor variables significantly differentiate "adopters", "considered", and "not considered", F(8, 390) = 3.91, $p < 0.001$. Since, MANOVA shows significant multivariate effects, the nature of relationships between the independent and dependent variables was further investigated. Three kinds of information were used to investigate these relationships. First, the degree to which predictor variables are intercorrelated provides information about the independence of effects being assessed. Pooled within-cell correlation is shown in Table 5-15a. Organizational size (Org. Size) and number of active projects in ISD (No. Proj.) are highly correlated with ISD ($r = 0.577$ and $r = 0.489$ respectively).

Second, although the statistical significance of univariate F values is misleading, they (Table 5-15a) were examined to see the effect each predictor variable would have had in isolation. As can be seen all variables have significant univariate F's.

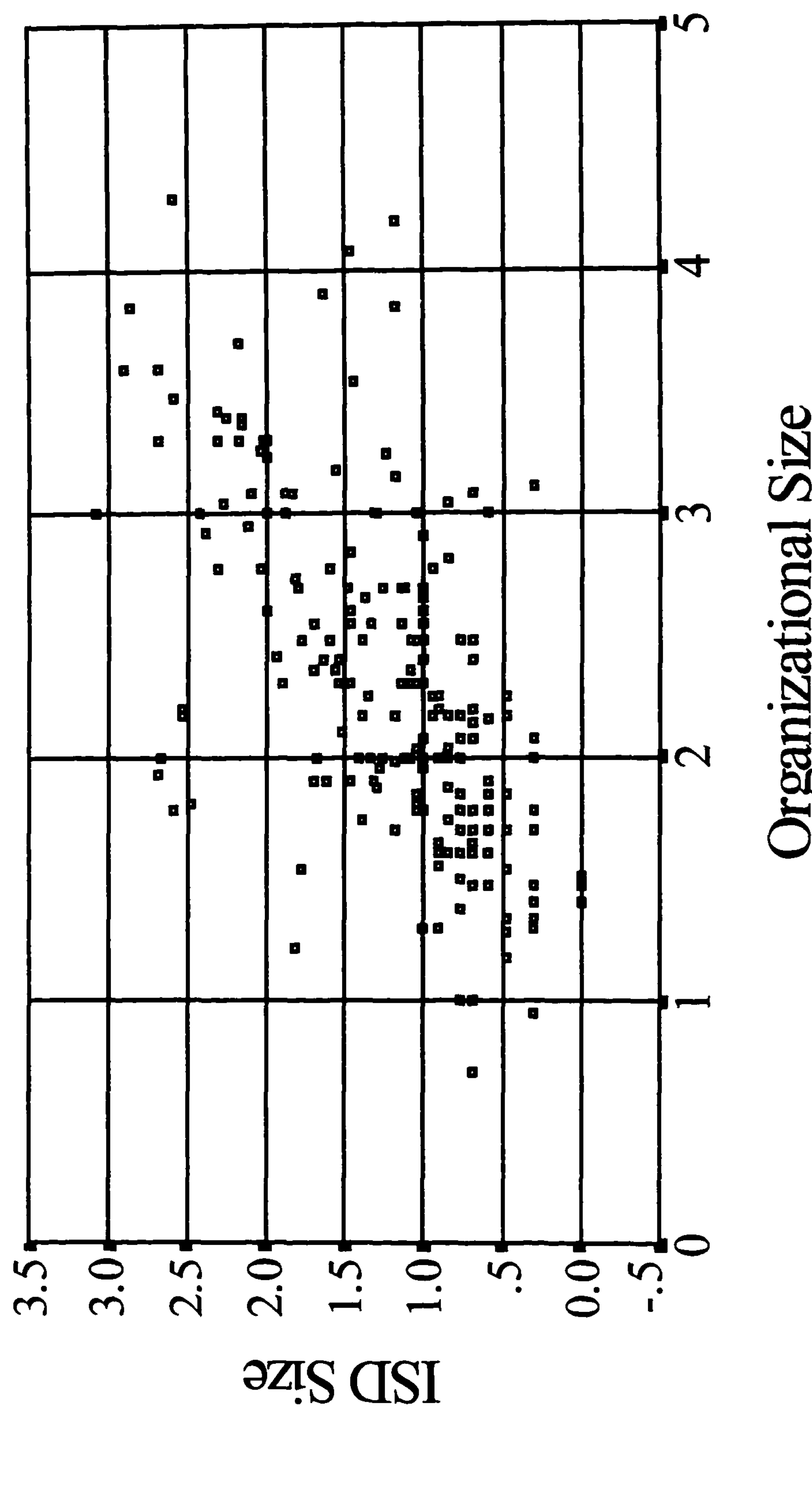

Figure 5-1. Scatterplot of Organizational Size & ISD Size

Table 5-15a. Results of MANOVA Analysis Between "Adopters", "Considered", and "Not Considered"

Multivariate Tests of Significance (S = 2, M = ½, N = 96 ½)

Test Name	Value	Approx. F	Hypoth. DF	Error DF	Sig. of F
Pillais	.14720	3.89281	8.00	392.00	.000
Hotellings	.16228	3.93541	8.00	388.00	.000
Wilks	.85687	3.91431	8.00	390.00	.000
Roys	.11030				

WITHIN CELLS Correlations with Std. Devs. on Diagonal

	Org. Size	ISD Size	No. Proj.	Devlopmt
Org. Size	.658			
ISD Size	.577	.619		
No. Proj.	.247	.489	.503	
Devlopmt	.121	.105	-.123	26.330

EFFECT .. ADOPTER (Cont.)
Univariate F-tests with (2,198) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
Org. Size	6.29303	85.66891	3.14652	.43267	7.27230	.001
ISD Size	7.55188	75.83000	3.77594	.38298	9.85938	.000
No. Proj.	2.12050	50.12176	1.06025	.25314	4.18840	.017
Devlopmt	5766.53480	137269.060	2883.26740	693.27808	4.15889	.017

EFFECT .. ADOPTER (Cont.)
Roy-Bargman Stepdown F - tests

Variable	Hypoth. MS	Error MS	StepDown F	Hypoth. DF	Error DF	Sig. of F
ISD Size	3.77594	.38298	9.85938	2	198	.000
Devlopmt	2455.82142	689.13730	3.56362	2	197	.030
Org. Size	.28987	.28985	1.00008	2	196	.370
No. Proj.	.25470	.18751	1.35833	2	195	.260

Finally, stepdown analysis allows a look at the significance of the predictor variables in context, with Type I error rate controlled. For the purpose of this study, the following priority of predictor variables was developed -- ISD size, proportion of development projects in ISD (Devlopmt), organizational size, and number of active projects in ISD. ISD size was given the highest priority as both organizational size and number of active projects are highly correlated with it. On the other hand, both are highly correlated with only ISD size ($r = 0.577$ and $r = 0.489$ respectively), but not with each other ($r = 0.247$). Also, there are fewer missing values for ISD size than either organizational size or number of active projects in ISD. Since, effect of both organizational size and number of active projects in ISD is taken into consideration by giving ISD size the highest priority through their high correlation with it, the proportion of development project is given the next highest priority. Organizational size and number of active projects in ISD are given next highest priority in that order. Results of stepdown analysis are shown in Table 5-15a.

A unique contribution to predicting differences between "adopters", "considered", and "not considered" groups is made by ISD size, stepdown $F(2, 198) = 9.86$, $p < 0.001$. "Adopters" had larger number of ISD employees (1.57[*]) than "considered" (1.47), which in turn had higher number of employees than "non-considered" (1.09). After the pattern of differences measured by ISD size was accounted for, a significant difference was also found on proportion of development projects, stepdown $F(2, 197) = 3.56$, $p < 0.05$.

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[*]Numbers in the parentheses are mean values of the related variables in the discussion.

"Considered" had higher proportion of development projects (53.12) than "adopters" (37.32). "Non-adopters" also had higher proportion of development projects in their ISD (39.21), albeit by a very small margin. After the effects of ISD size and proportion of development projects in ISD were factored in, organizational size and number of active projects in ISD were found no more significant in differentiating the three groups.

5.7.1.2 "Adopters" and "Non-Adopters"

A test for homogeneity of covariance matrices performed through SPSS MANOVA produced $F(10, 7767) = 1.26$, $p > 0.05$ for Box's M, indicating that there was no statistically significant deviation from homogeneity of covariance matrices. Bartlett test of sphericity (157.44) with 6 d.f. was found significant at $p < 0.001$, and hence multicollinearity and singularity were also judged not to be a problem.

Three parallel tests of significance shown in Table 5-15b show significant effects, with Wilks' Lambda = 0.9435, $F(4, 196) = 2.94$, $p < 0.05$. Since, MANOVA shows significant multivariate effects, the nature of relationships between the independent and dependent variables was further investigated. Pooled within-cell correlation is shown in Table 5-15b show both organizational size and number of active projects in ISD highly correlated with ISD size ($r = 0.595$ and $r = 0.509$ respectively). The univariate F's indicate that both ISD size and organizational size are significant.

Results of stepdown analysis (Table 5-15b) show that a unique contribution to predicting differences between "adopters" and "non-adopters" groups is made by ISD size, stepdown $F(1, 199) = 8.82$, $p < 0.005$. "Adopters" employed larger number of ISD employees (1.57) than "non-adopters" (1.17). No other variable was found to differentiate

Table 5-15b. Results of MANOVA Analysis Between "Adopters" and "Non-Adopters"

EFFECT .. ADOPTER1
Multivariate Tests of Significance (S = 1, M = 1 , N = 97)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.05655	2.93725	4.00	196.00	.022
Hotellings	.05994	2.93725	4.00	196.00	.022
Wilks	.94345	2.93725	4.00	196.00	.022
Roys	.05655				

Note.. F statistics are exact.

WITHIN+RESIDUAL Correlations with Std. Devs. on Diagonal

	ISD Size	Devlopmt	Org. Size	No. Proj.
ISD Size	.633			
Devlopmt	.144	26.767		
Org. Size	.595	.153	.668	
No. Proj.	.509	-.084	.273	.510

EFFECT .. ADOPTER1 (Cont.)
Univariate F-tests with (1,199) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ISD Size	3.53906	79.84283	3.53906	.40122	8.82074	.003
Devlopmt	457.96663	142577.628	457.96663	716.47049	.63920	.425
Org. Size	3.08776	88.87418	3.08776	.44660	6.91387	.009
No. Proj.	.45715	51.78511	.45715	.26023	1.75674	.187

Roy-Bargman Stepdown F - tests

Variable	Hypoth. MS	Error MS	StepDown F	Hypoth. DF	Error DF	Sig. of F
ISD Size	3.53906	.40122	8.82074	1	199	.003
Devlopmt	1030.76616	705.25720	1.46155	1	198	.228
Org. Size	.38092	.28939	1.31630	1	197	.253
No. Proj.	.03079	.18900	.16292	1	196	.687

the two groups significantly.

5.7.1.3 "Adopters" and "Considered"

As indicated earlier, capability, efficiency, and complexity of CASE tools were also used besides the four demographic variables in the MANOVA analysis involving "adopters" and "considered" as data on these variables were available for these groups.

A test for homogeneity of covariance matrices performed through SPSS MANOVA produced F (28, 9269) = 0.88, $p > 0.05$ for Box's M, indicating that there was no statistically significant deviation from homogeneity of covariance matrices. Bartlett's test of sphericity (94.64) with 21 d.f. was found significant at $p < 0.001$, and hence multicollinearity and singularity were also judged not to be a problem.

Three parallel tests of significance shown in Table 5-15c show no significant effects, with Wilks' Lambda = 0.7552, F(7, 49) = 2.27, $p < 0.05$. Since, MANOVA shows significant multivariate effects, the nature of relationships between the independent and dependent variables was further investigated. Pooled within-cell correlations (Table 5-15c) show that both organizational size and number of active projects are highly correlated with ISD size ($r = 0.733$ and $r = 0.603$ respectively). Efficiency is moderately related to ISD size (although negatively), while complexity is moderately related to efficiency ($r = -0.82$). The univariate F's (Table 5-15c) show that only proportion of development projects is significant in differentiating "adopters" from "considered".

The results of stepdown analysis are shown in Table 5-15c. The variables were entered in the analysis in the following priority -- ISD size, proportion of development projects in ISD, capability, efficiency, complexity, organizational size, and number of

Table 5-15c. Results of MANOVA Analysis Between "Adopters" and "Considered"

EFFECT .. ADOPTERC
Multivariate Tests of Significance (S = 1, M = 2 ½, N = 23 ½)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.24480	2.26901	7.00	49.00	.044
Hotellings	.32414	2.26901	7.00	49.00	.044
Wilks	.75520	2.26901	7.00	49.00	.044
Roys	.24480				

Note.. F statistics are exact.

WITHIN+RESIDUAL Correlations with Std. Devs. on Diagonal

	ISD Size	Devlopmt	CAPBLITY	EFFICNY	COMPLEX	Org Size	No. Proj.
ISD Size	.647						
Devlopmt	.138	20.780					
CAPBLITY	-.101	.184	2.728				
EFFICNY	-.284	.135	.092	3.501			
COMPLEX	.107	.031	.000	-.382	4.891		
Org. Size	.733	.248	.024	-.072	.116	.722	
No. Proj.	.603	-.125	-.046	-.129	.056	.323	.522

EFFECT .. ADOPTERC (Cont.)
Univariate F-tests with (1,55) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ISD Size	.11691	23.02329	.11691	.41861	.27929	.599
Devlopmt	2922.45474	23749.4400	2922.45474	431.80800	6.76795	.012
CAPBLITY	17.83428	409.30910	17.83428	7.44198	2.39644	.127
EFFICNY	9.75634	674.27875	9.75634	12.25961	.79581	.376
COMPLEX	29.05265	1315.50875	29.05265	23.91834	1.21466	.275
Org. Size	.13040	28.68229	.13040	.52150	.25006	.619
No. Proj.	.00416	14.95858	.00416	.27197	.01530	.902

EFFECT .. ADOPTERC (Cont.)
Roy-Bargman Stepdown F - tests

Variable	Hypoth. MS	Error MS	StepDown F	Hypoth. DF	Error DF	Sig. of F
ISD Size	.11691	.41861	.27929	1	55	.599
Devlopmt	3072.82895	431.44582	7.12217	1	54	.010
CAPBLITY	30.00409	7.33488	4.09060	1	53	.048
EFFICNY	21.16878	11.50439	1.84006	1	52	.181
COMPLEX	5.72653	21.83003	.26232	1	51	.611
Org. Size	.02219	.23819	.09314	1	50	.761
No. Proj.	.30146	.16928	1.78079	1	49	.188

active projects in ISD. The results show that a unique contribution to predicting differences between adopters and considered groups is made by proportion of development projects, stepdown $F(1, 54) = 7.12$, $p < 0.05$. "Adopters" had smaller proportion of development projects (37.32%) than "considered" (51.75%) group. After the effect of proportion of development projects was accounted for, capability of CASE tools was also found significant, stepdown $F(1, 53) = 4.09$, $p < 0.05$. "Adopters" perceived capability of CASE tools higher (16.48) than "considered" (15.35), and that is probably why they adopted them.

5.7.1.4 "Considered" and "Not Considered"

A test for homogeneity of covariance matrices performed through SPSS MANOVA produced $F(10, 59699) = 1.52$, $p > 0.05$ for Box's M, indicating that there was no statistically significant deviation from homogeneity of covariance matrices. Bartlett's test of sphericity (143.51) with 6 d.f. was found significant at $p < 0.001$, and hence multicollinearity and singularity were also judged not to be a problem.

All three parallel tests of significance shown in Table 5-15d show significant effects, with Wilks' Lambda = 0.8902, $F(4, 196) = 6.05$, $p < 0.001$. Since MANOVA shows significant multivariate effects, the nature of relationships between the independent and dependent variables was further investigated. Pooled within-cell correlation (Table 5-15d) show that both organizational size ($r = 0.578$) and number of active projects in ISD ($r = 0.487$) are highly correlated with ISD size. The univariate F's (Table 5-15d) indicate that ISD size, organizational size, and number of active projects in ISD are significant.

Table 5-15d. Results of MANOVA Analysis Between "Considered" and "Not Considered"

EFFECT .. CONSIDRD
Multivariate Tests of Significance (S = 1, M = 1 , N = 97)

Test Name	Value	Exact F	Hypoth. DF	Error DF	Sig. of F
Pillais	.10983	6.04558	4.00	196.00	.000
Hotellings	.12338	6.04558	4.00	196.00	.000
Wilks	.89017	6.04558	4.00	196.00	.000
Roys	.10983				

Note.. F statistics are exact.

WITHIN+RESIDUAL Correlations with Std. Devs. on Diagonal

	ISD Size	Devlopmt	Org. Size	No. Proj.
ISD Size	.618			
Devlopmt	.097	26.606		
Org. Size	.578	.113	.657	
No. Proj.	.487	-.116	.246	.502

EFFECT .. CONSIDRD (Cont.)
Univariate F-tests with (1,199) D. F.

Variable	Hypoth. SS	Error SS	Hypoth. MS	Error MS	F	Sig. of F
ISD Size	7.42594	75.95595	7.42594	.38169	19.45551	.000
Devlopmt	2171.09744	140864.498	2171.09744	707.86180	3.06712	.081
Org. Size	6.14960	85.81235	6.14960	.43122	14.26100	.000
No. Proj.	2.07824	50.16403	2.07824	.25208	8.24435	.005

Roy-Bargman Stepdown F - tests

Variable	Hypoth. MS	Error MS	StepDown F	Hypoth. DF	Error DF	Sig. of F
ISD Size	7.42594	.38169	19.45551	1	199	.000
Devlopmt	1130.12502	704.75539	1.60357	1	198	.207
Org. Size	.51677	.28870	1.79001	1	197	.182
No. Proj.	.22002	.18803	1.17011	1	196	.281

Stepdown analysis (Table 5-15d) shows that a unique contribution to predicting differences between "considered" and "not considered" groups is made by only ISD size, stepdown $F(1, 199) = 19.46$, $p < 0.001$. "Considered" had a larger number of ISD employees (1.51) than "not considered" group (1.09). After the effect of ISD size was accounted for, no other variables were found significant in differentiating the two groups.

Table 5-16 shows a comparison of univariate ANOVA and stepdown MANOVA results.

5.7.2 Discriminant Function Analysis

The major purpose of discriminant analysis is to predict group membership on the basis of a number of predictor variables. It determines the best combination of predictor variables to maximize differences among groups. In MANOVA, a test is done to determine whether group membership produces significant differences on a combination of variables. If MANOVA shows significant differences, then using discriminant function analysis that combination of variables can be used to discriminate among groups (Tabachnick and Fidell, 1989). The analysis described below establishes a predictive model of adoption by identifying a group of variables that have the strongest power in distinguishing between the groups of "adopters", "considered", and "not considered".

To interpret the relative predictive power of each independent variable in the light of multicollinearity, the discriminant loadings, also known as structure correlations are considered relatively more valid than standardized coefficients (Hair, Anderson, and Tathom, 1987). As indicated by Johnston (1984), bias starts to creep into the model when intervariable correlations exceed 0.5, becoming serious at correlations over 0.7, and

Table 5-16. A Comparison of Univariate ANOVA and MANOVA Results

Groups	Variables	Univariate ANOVA	Stepdown MANOVA
"Adopters", "Considered", and "Not Considered"	Organizational Size	significant***	not significant
	ISD Size	significant***	significant***
	No. of Active Projects in ISD	significant*	not significant
	Proportion of Development Projects	significant*	significant*
"Adopters" and "Non-Adopters"	Organizational Size	significant**	not significant
	ISD Size	significant**	significant**
	No. of Active Projects in ISD	not significant	not significant
	Proportion of Development Projects	not significant	not significant
"Adopters" and "Considered"	Organizational Size	not significant	not significant
	ISD Size	not significant	not significant
	No. of Active Projects in ISD	not significant	not significant
	Proportion of Development Projects	significant*	significant*
	Capability of CASE	not significant	significant*
	Efficiency of CASE	not significant	not significant
	Complexity of CASE	not significant	not significant
"Considered" and "Not Considered"	Organizational Size	significant***	not significant
	ISD Size	significant***	significant***
	No. of Active Projects in ISD	significant**	not significant
	Proportion of Development Projects	not significant	not significant

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

causes contribution to be shared in the standardized coefficients. The overall effectiveness of the function is measured using the significance of Wilks λ and χ^2. Both these measures test the hypothesis that there is no difference in the group means of the population.

Even though the discriminant function may be statistically significant, it may not do very well in classifying cases. Green (1978) calls this illustration of the difference between statistical and operational difference. To estimate the effectiveness of the discriminant function as a predictive model, the classification table must be interpreted. The classification accuracy of the discriminant function(s) was compared with classification accuracy of a chance model (Hair, et al., 1983), whose accuracy is given by the formula, $C = s^2 + (1 - s)^2$, where s is the proportion of the sample in the first group. To determine statistically if the classification ability of the discriminant model is better than the chance model, a t-test on the accuracy of the two models was performed (Hair, et al., 1983), with t-value being calculated as:

$$t = \frac{p - k}{\sqrt{\frac{k(1-k)}{n}}}$$

p = proportion correctly classified

k = chance accuracy

n = sample size.

To prevent an upward bias in classification, analyses were also performed with split sample, with one half deriving the function and the other half assessing its effectiveness. To identify variables which uniquely contribute to the difference between different groups, hierarchical and stepwise analyses were also performed with split sample.

5.7.2.1 "Adopters", "Considered", and "Not Considered"

A direct discriminant analysis with the entire sample was performed using the four demographic variables -- organizational size, ISD size, number of active projects in the ISD, and proportion of development projects in the ISD as predictors of membership in three groups -- "adopters", "considered", and "not considered". Evaluation of assumptions of linearity, normality, multicollinearity or singularity, and homogeneity of variance-covariance matrices revealed no problem to multivariate analysis.

Two discriminant functions were calculated, with a combined $\chi^2(8) = 30.35$, $p < 0.001$. After removal of the first function, the second function did not have significant discriminating power at 0.05 level of significance, $\chi^2(3) = 7.39$, $p > 0.05$, however, it was very close to being significant ($p = 0.0605$). The two discriminant functions accounted for 76.4 percent and 23.6 percent of the between-group variability respectively. They also explained 11.03 percent and 3.69 percent of the total variance.

As shown in Figure 5-2, the first discriminant function maximally separates "adopters" from "not considered". The second discriminant function discriminates "adopters" from "considered". A loading matrix of correlations between predictor variables and discriminant functions (shown in Table 5-17a as discriminant powers of different variables) suggests that the primary variable in distinguishing between "adopters" and "not considered" (first function) is ISD size. "Adopters" have higher number of ISD employees (1.57)* than "not considered" (1.09). Also contributing to

*Numbers in the parentheses are mean values of the related variables.

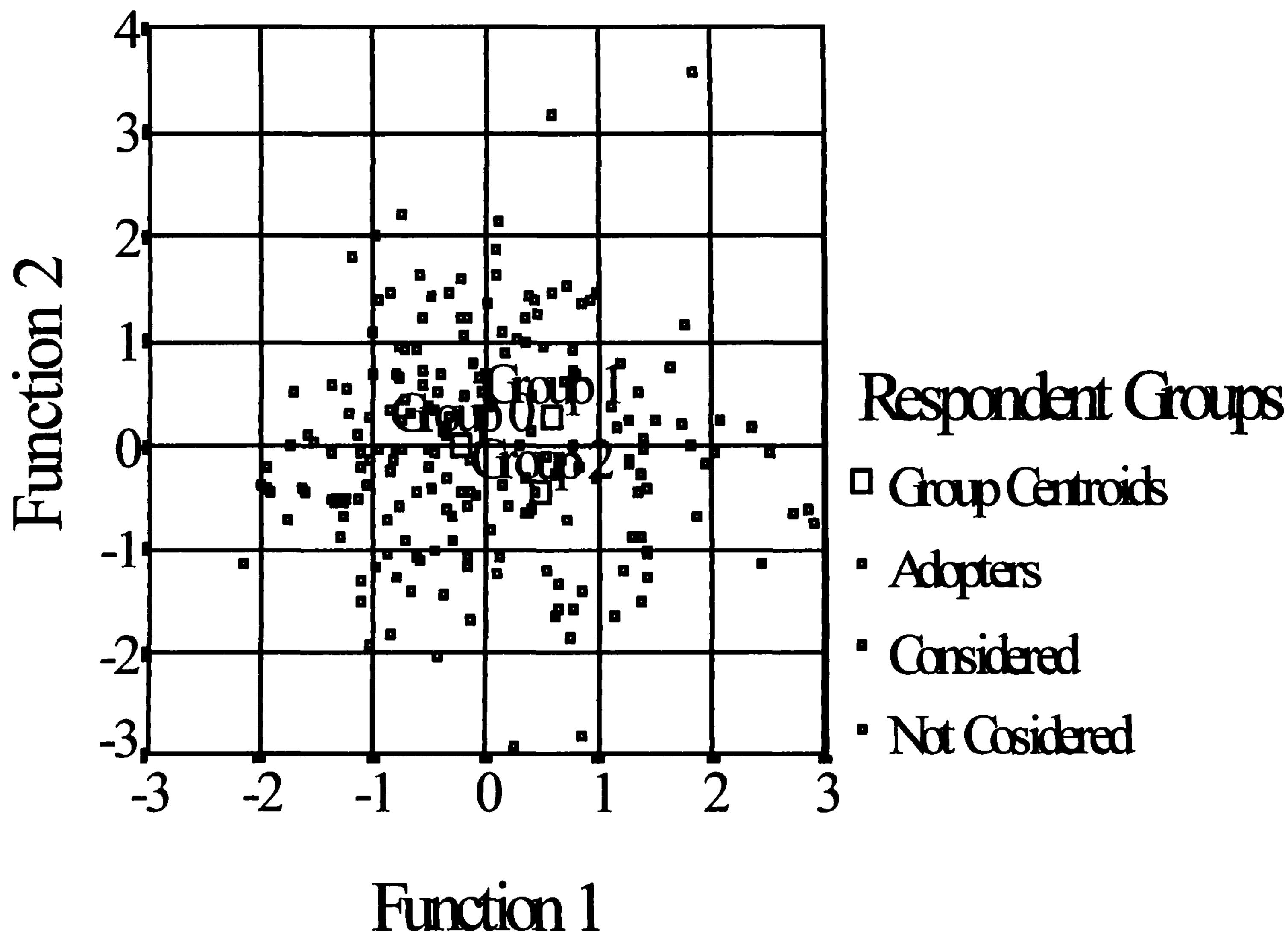

Figure 5-2. Plot of Canonical Discriminant Functions

Table 5-17a. Direct Discriminant Analysis Between "Adopters", "Considered", and "Not Considered" With Complete Sample

Function	Significance of Discriminant Function			Classification Accuracy		
	Wilks' λ	χ^2	p-value	Accuracy	t	sig.
Function 1	0.8569	$\chi^2(8) = 30.35$	0.0002	68.66%	2.92	0.005
Function 2	0.9631	$\chi^2(3) = 7.39$	0.0605			

Variables	Mean			Standardized Discriminant Coefficients		Discriminant Power	
	Adopter	Considered	Not Considered	Func. 1	Func. 2	Func. 1	Func. 2
Organizational Size	2.62	2.52	2.17	0.3499	-0.2435	0.7491	-0.3186
ISD Size	1.57	1.47	1.09	0.4949	-0.5361	0.8766	-0.3362
Number of Active Projects in ISD	1.20	1.26	1.01	0.2957	0.4991	0.5831	0.0642
Proportion of Development Projects in ISD	37.32	53.12	39.21	0.3351	0.9123	0.3930	0.7725

discrimination between these two groups is organizational size and number of active projects. "Adopters" had larger annual sales turnover (2.62) than "not considered" (2.17). "Adopters" also had higher number of active projects (1.20) than "not considered" (2.17). (Loadings less than 0.45 are not interpreted (Tabachnick and Fidell, 1989).) Only proportion of development projects in ISD distinguishes "adopters" from "considered" (second function), which is not significant at $\alpha = 0.05$. The overall classification accuracy is 68.66 percent when prior probabilities are taken in the proportion of group sizes. The chance accuracy is 58.53 percent (s = 0.7065). A t-test showed that difference is significant at 0.005 level of significance. A hierarchical analysis with the variables entered in the order of ISD size, proportion of development project, ISD size, and number of active projects showed similar results.

A direct analysis done with split sample showed (see Table 5-17b) that the classification accuracy for the sample from which discriminant function was derived is 67.62 percent. For the cross-validation sample, classification accuracy is 68.75 percent. This indicates a high degree of consistency in the classification scheme.

A stepwise analysis showed that only organizational size significantly differentiated the three groups (Wilks' lambda = 0.8718, chi-square(2) = 12.63, $p < 0.01$. Classification accuracy was 64.08 percent and 65.22 percent for the used (to derive discriminant functions) and cross-validation samples.

5.7.2.2 "Adopters" and "Non-Adopters"

A direct discriminant analysis with the complete sample with four demographic variables showed that discriminant function was significant (Wilks' lambda = 0.9434, χ^2

Table 5-17b. Direct Discriminant Analysis Between "Adopters", "Considered", and "Not Considered" With Split Sample

Function	Significance of Discriminant Function			Overall Classification Accuracy	
	Wilks' λ	χ^2	p-value	Original	Cross-Validation
Function 1	0.8419	$\chi^2(8) = 17.30$	0.0271	67.62%	68.75%
Function 2	0.9727	$\chi^2(3) = 2.79$	0.4260		

Variables	Mean			Standardized Discriminant Coefficients		Discriminant Power	
	Adopter	Considered	Not Considered	Func. 1	Func. 2	Func. 1	Func. 2
Organizational Size	2.61	2.59	2.21	0.1874	0.0803	0.6616	-0.1156
ISD Size	1.59	1.52	1.09	0.7968	-0.7615	0.9163	-0.2959
Number of Active Projects	1.16	1.20	1.04	-0.0981	0.5277	0.3150	0.1105
Proportion of Development Projects	41.13	54.56	36.68	0.3457	0.9349	0.5117	0.7762

(4) = 11.47, $p < 0.05$), explaining 5.65 percent of the variance. A loading matrix of correlations between predictor variables and discriminant functions (Table 5-18a) shows that the primary variable in distinguishing between "adopters" and "non-adopters" is ISD size. "Adopters" had higher number of ISD employees (1.57) than "non-adopters" (1.16). Also contributing to discrimination between these two groups is organizational size. "Adopters" had larger annual sales turnover (2.62) than "non-adopters" (2.24). The overall classification accuracy is 85.57 percent. The chance accuracy is 77.48 percent (s = 0.8706). A t-test showed that difference is significant at 0.005 level of significance. A hierarchical analysis showed the similar results.

A direct discriminant analysis with the four demographic variables and split sample showed (Table 5-18b) that discriminant function was not significant (Wilks' lambda = 0.9414, χ^2 (4) = 5.50, p = 0.2398).

A stepwise analysis, however, showed that only ISD size and proportion of development projects in the ISD significantly differentiated the three groups (Wilks' lambda = 0.8999, $\chi^2(2) = 9.50$, $p = 0.0087 < 0.01$). The primary variable in differentiating the two groups was ISD size, followed by proportion of development projects in the ISD. Classification accuracy was 81.58 percent and 79.78 percent for the hold-out and cross-validation samples.

5.7.2.3 "Adopters" and "Considered"

A direct discriminant analysis with the complete sample with four demographic variables and three technological characteristics variables -- capability, efficiency, and complexity of CASE tools showed that discriminant function was significant (Wilks'

Table 5-18a. Direct Discriminant Analysis Between "Adopter" and "Non-Adopters" With Complete Sample

Significance of Discriminant Function			Overall Classification Accuracy		
Wilks' λ	χ^2	p-value	Accuracy	t	sig.
0.9434	$\chi^2(4) = 11.47$	0.0218	85.57%	2.75	0.005

Variables	Mean		Standardized Discriminant Coefficients	Discriminant Power
	Adopter	Non-Adopter		
Organizational Size	2.62	2.24	0.4233	0.7613
ISD Size	1.57	1.16	0.7405	0.8599
Number of Active Projects	1.20	1.06	-0.1433	0.3838
Proportion of Development Projects	37.32	41.89	-0.4145	-0.2315

Table 5-18b. Direct Discriminant Analysis Between "Adopters" and "Non-Adopters" With Split Sample

Significance of Discriminant Function			Overall Classification Accuracy	
Wilks' λ	χ^2	p-value	Original	Cross-Validation
0.9414	$\chi^2(4) = 5.50$	0.2398	84.21%	84.91%

Variables	Mean		Standardized Discriminant Coefficients	Discriminant Power
	Adopter	Non-Adopter		
Organizational Size	2.52	2.22	0.5046	0.6988
ISD Size	1.47	1.19	0.4549	0.6662
Number of Active Projects	1.21	1.07	0.2074	0.4386
Proportion of Development Projects	33.87	41.80	-0.5672	-0.4547

lambda = 0.7552, χ^2 (7) = 14.46, $p < 0.05$), explaining 24.48 percent of the variance. A loading matrix of correlations between predictor variables and discriminant functions (Table 5-19a) suggests that the primary variable in distinguishing between "adopters" and "considered" is proportion of development projects in the ISD. "Adopters" had lower proportion of development projects (37.32) than "considered" (51.75). No other variable had a loading equal to or exceeding 0.45, and hence its effect is not discussed. The overall classification accuracy is 75.44 percent, while the chance accuracy is 50.75 percent (s = 0.5614). A t-test showed that difference is significant at 0.005 level of significance.

A direct discriminant analysis with split sample showed (Table 5-19b) that discriminant function was not significant (Wilks' lambda = 0.7399, χ^2 (7) = 8.59, p = 0.2838) at 0.05 significance level.

A stepwise analysis showed that no variable significantly differentiated the two groups at 0.05 level of significance.

5.7.2.4 "Considered" and "Not Considered"

A direct discriminant analysis with complete sample with four demographic variables showed that discriminant function was significant (Wilks' lambda = 0.8902, χ^2 (4) = 22.92, $p < 0.001$), explaining 10.98 percent of the variance. A loading matrix of correlations between predictor variables and discriminant functions (Table 5-20a) shows that the primary variable distinguishing "considered" from "not considered" is ISD size."Considered" have higher number of ISD employees (1.51) than "not considered" (1.09). Also contributing to discrimination between these two groups is organizational

Table 5-19a. Direct Discriminant Analysis Between "Adopters" and "Considered" With Complete Sample

Significance of Discriminant Function			Overall Classification Accuracy		
Wilks' λ	χ^2	p-value	Accuracy	t	sig.
0.7552	$\chi^2(7) = 14.46$	0.0436	75.44	3.73	0.005

Variables	Mean		Standardized Discriminant Coefficients	Discriminant Power
	Adopter	Considered		
Organizational Size	2.62	2.52	0.0049	0.1184
ISD Size	1.57	1.48	0.7347	0.1252
Number of Active Projects	1.20	1.22	-0.5083	-0.0293
Proportion of Development Projects	37.32	51.75	-0.9307	-0.6161
Capability	16.48	15.35	0.5540	0.3666
Efficiency	14.24	13.41	0.3767	0.2113
Complexity	15.28	16.72	0-0.1396	-0.2610

Table 5-19b. Direct Discriminant Analysis Between "Adopters" and "Considered" With Split Sample

Significance of Discriminant Function			Overall Classification Accuracy	
Wilks' λ	χ^2	p-value	Original	Cross-Validation
0.2838	$\chi^2(4) = 8.586$	0.2838	67.65%	60.87%

Variables	Mean		Standardized Discriminant Coefficients	Discriminant Power
	Adopter	Considered		
Organizational Size	2.47	2.44	0.2887	0.0291
ISD Size	1.60	1.47	0.8950	0.1700
Number of Active Projects	1.19	1.26	-1.0897	-0.1130
Proportion of Development Projects	39.33	51.11	-1.0268	-0.4745
Capability	5.24	4.99	0.4885	0.2493
Efficiency	4.88	4.68	0.7380	0.1568
Complexity	3.95	4.13	0.0714	-0.1171

Table 5-20a. Direct Discriminant Analysis Between "Considered" and "Not Considered" With Complete Sample

Significance of Discriminant Function			Overall Classification Accuracy		
Wilks' λ	χ^2	p-value	Accuracy	t	sig.
0.8902	$\chi^2(4) = 22.92$	0.0001	65.67%	2.055	0.05

Variables	Mean		Standardized Discriminant Coefficients	Discriminant Power
	Considered	Not Considered		
Organizational Size	2.56	2.17	0.3615	0.7621
ISD Size	1.51	1.09	0.5207	0.8902
Number of Active Projects	1.24	1.01	0.2712	0.5795
Proportion of Development Projects	46.42	39.21	0.2938	0.3534

size and number of active projects in ISD. “Considered” had larger annual sales turnover (2.56) and had more active projects (1.24) than “not considered” (2.17 and 1.01 respectively). The overall classification accuracy is 65.67 percent. The chance accuracy is 58.53 percent (s = 0.7065). A t-test showed that difference is significant at 0.005 level of significance. A hierarchical analysis showed similar results.

A direct discriminant analysis with the four demographic variables with split sample showed (Table 5-20b) that discriminant function was significant (Wilks' lambda = 0.8826, chi-square (4) = 11.49, p = 0.0216) at 0.05 significance level, explaining 11.74 percent of the variance (canonical correlation of the discriminant function = 0.3427). An examination of the structure matrix showed that important variables in differentiating "considered" from "not considered" are number of active projects in the ISD, ISD size, and organizational size in the order of importance. "Considered" had more active projects (1.26), bigger ISD (1.48), and larger organization (2.54) than "not considered" (0.99, 1.10, and 2.19 respectively). The classification accuracy of the used and cross-validation sample is 68.75 percent and 60.00 percent respectively.

A stepwise analysis showed that only number of active projects differentiated the two groups (Wilks' lambda = 0.9458, chi-square(1) = 5.38, p = 0.0204 < 0.05). Classification accuracy was 56.95 percent and 47.80 percent for the used and cross-validation samples.

Table 5-21 shows a summary of discriminant analysis results. It also shows a comparison of discriminant results with stepdown MANOVA results. The results of the stepdown MANOVA seem consistent with the results of direct discriminant analysis to a

Table 5-20b. Direct Discriminant Analysis Between "Considered" and "Not Considered" With Split Sample

Significance of Discriminant Function			Overall Classification Accuracy	
Wilks' λ	χ^2	p-value	Original	Cross-Validation
0.8826	$\chi^2(4) = 11.49$	0.0216	68.75%	60.00%

Variables	Mean		Standardized Discriminant Coefficients	Discriminant Power
	Considered	Not Considered		
Organizational Size	2.54	2.19	0.3675	0.7090
ISD Size	1.48	1.10	0.2097	0.7767
Number of Active Projects	1.25	0.98	0.5983	0.7826
Proportion of Development Projects	45.89	38.27	0.2992	0.3624

Table 5-21. Summary of Discriminant and MANOVA Analysis Results

Groups	Variables	Discriminant Analysis		MANOVA
		Direct	Stepwise	
		significance	significance	significance
"Adopters", "Considered", and "Not Considered"	Organizational Size	2#	1	not significant
	ISD Size	1		significant***
	No. of Active Projects in ISD	3		not significant
	Proportion of Development Projects in ISD			significant*
"Adopters" and "Non-Adopters"	Organizational Size	2		not significant
	ISD Size	1	1	significant**
	No. of Active Projects in ISD			not significant
	Proportion of Development Projects in ISD		2	not significant
"Adopters" and "Considered"	Organizational Size			not significant
	ISD Size			not significant
	No. of Active Projects in ISD			not significant
	Proportion of Development Projects in ISD	1		significant*
	Capability of CASE			significant*
	Efficiency of CASE			not significant
	Complexity of CASE			not significant
"Considered" and "Not Considered"	Organizational Size	2		not significant
	ISD Size	1		significant***
	No. of Active Projects in ISD	3	1	not significant
	Proportion of Development Projects in ISD			not significant

The numbers show order of importance of variables in their effect in discriminating between different groups. If a variance does not having a loading of 0.45 or above, it is not assigned any number. If a test is not significant, none of the variables for that test is assigned any number.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

large extent in identifying important variables which distinguish one group of organizations from another.

5.8 Robust Regression

The method of least squares and its generalization are considered as cornerstones in the estimation of parameters associated with regression analysis. By most optimization criteria, ordinary least squares (OLS) estimates are known to be the best when data follow a normal error structure. The presence of outliers, however, may distort the estimates. Outliers have unusually large influence on the least square estimators.

Two approaches have been suggested to address the problem of outliers (Rousseeuw and Leroy, 1987). The first approach is to compute so called regression diagnostics. Diagnostics are statistics computed from the data with the purpose of identifying cases or observations which unduly affect regression estimates (that is, outliers). Using diagnostics, outliers can be removed or modified, and an OLS can be performed on the remaining cases to get a undistorted estimates of regression coefficients. When there is only a single outlier, this method works quite well. However, it is much more difficult to diagnose outliers when there are several of them. Diagnostics for such multiple outliers is quite involved and often give rise to extensive computations. Moreover, since the outliers pull the least squares "fit" towards them too much, examination of the residuals is misleading (which most of diagnostics use) because then the residuals look more like normal ones.

To overcome this problem a second approach which uses robust methods has been developed to modify least squares procedures so that outliers have much less influence on the final estimates. In different methods of robust regression, a function of the residuals is selected and the regression coefficients are obtained by minimizing the sum of this function of the residuals. The form of these functions is chosen in such a way that observations with unusually large residuals are weighted only marginally. Contrary to this, the OLS estimates for the regression coefficients are obtained by minimizing the sum of the squared residuals. The outliers or abnormal observations substantially contribute to the sum of squares error, and thus influence the regression line to a large degree.

OLS analyses performed for each independent variables in the research model with adoption and infusion as dependent variables showed some outlying cases for the majority of independent-dependent variable pairs. Hence, it was decided to perform robust regression analyses. There are many methods of robust regression. Widely used among them are methods using weighted least squares, least-absolute residuals, Huber M estimate, R estimate, L estimate, and estimates based on the redescending psi functions put forward by Hampel, Andrews (the sine estimate), and Tukey (the biweight estimate) (Huynh, 1982; Hogg, 1979; Hill and Holland, 1977). Weighted least squares (WLS) method is used here.

Weighted least squares methods determine regression parameters by minimizing weighted residual sum of squares. Observations with high absolute values of residuals are given less weight than observations which are normal (that is, which have low absolute values of residuals). Thus deviant observations contribute less to the residual sum of squares than normal observations.

Studentized residuals which are computed by dividing estimated residuals by the corresponding standard error were used to weigh outlying cases less than others. Since values of student t distribution do not generally exceed 2.5 in absolute value (except when n is large or degrees of freedom are small), studentized residuals can be used to detect outliers. To minimize the effect of outliers, the cases close to the mean of the distribution were given higher weights than cases away from it. Cases which had a studentized residual greater than 1.5 or less than -1.5 were given half the weight of the other cases. Using these weights, regression equations were fit and refit till parameter estimates became stable.

Since our purpose in this research has been to determine the direct effects of different independent variables on the two measures of diffusion, adoption and infusion, WLS was first performed with just one independent variable for both adoption and infusion at a time. Table 5-22a and Table 5-22b show parameter estimates, r^2, adjusted r^2, F values, and p-values for different robust regression analyses performed for each of the independent variables with the two dependent variables adoption and infusion. Later we perform WLS with all the variables in a group of variables in the research model (see Figure 3-1) for all the groups to discern their combined effect on dependent variables.

5.8.1 Results of Robust Regression Analyses

As seen in Table 5-22a, both organizational size ($p < 0.05$) and ISD size ($p < 0.01$) are significantly related to adoption. Many past studies have shown a direct relationship between organizational size and adoption of innovations (Armour and Teece,

Table 5-22a. Results of Robust Regression Analysis with Adoption as Dependent Variable

Variable	Parameter Estimate	R-square	Adjusted R-square	F-value	p-value
Organization size	0.0863	0.1450	0.1219	6.274	0.0084
ISD size	0.1251	0.1951	0.1727	8.725	0.0028
Number of active projects in ISD	-0.0361	0.0113	-0.0206	0.354	0.2782
Proportion of development projects	0.0010	0.0441	0.0142	1.476	0.1166
Prior experience of IS Personnel	-0.0065	0.0137	-0.0145	0.486	0.2451
Career orientation compatibility of IS personnel	0.0088	0.0265	-0.0013	0.952	0.1680
Multiskilled IS personnel	-0.0008	0.0003	-0.0283	0.010	0.4598
Perceived capability	0.0223	0.1513	0.1278	6.419	0.0079
Perceived efficiency	0.0179	0.1412	0.1167	5.757	0.0110
Perceived complexity	-0.0038	0.0145	-0.0128	0.531	0.2355
Stability of CASE toolset	0.0094	0.1327	0.1086	5.509	0.0123
Training and human resources development	0.0027	0.0090	-0.0193	0.317	0.2884
In-house vendor support	0.0100	0.0480	0.0208	1.763	0.0964
On-line vendor support	0.0032	0.0070	-0.0213	0.248	0.3108
Environmental scanning	0.0165	0.1643	0.1423	7.470	0.0048
Job/role rotation	0.0285	0.2444	0.2229	11.324	0.0010
Media richness of communication channels	0.0133	0.4348	0.4203	29.999	0.0000
Turnover of (managerial) IS personnel	-0.0085	0.0074	-0.0210	0.261	0.3064
Turnover of (technical) IS personnel	0.0195	0.2182	0.1965	10.049	0.0016

Table 5-22b. Results of Robust Regression Analysis with Infusion as Dependent Variable

Variable	Parameter Estimate	R-square	Adjusted R-square	F-value	p-value
Organization size	0.0214	0.0125	-0.0128	0.493	0.2435
ISD size	0.0354	0.0217	-0.0040	0.844	0.1821
Number of active projects in ISD	-0.0202	0.0073	-0.0228	0.243	0.3126
Proportion of development projects	0.0003	0.0023	-0.0246	0.086	0.3855
Prior experience of IS Personnel	-0.0020	0.0017	-0.0239	0.065	0.4002
Career orientation compatibility of IS personnel	0.0065	0.0162	-0.0090	0.643	0.2137
Multiskilled IS personnel	-0.0033	0.0069	-0.0186	0.270	0.3031
Perceived capability	0.0150	0.0795	0.0559	3.369	0.0371
Perceived efficiency	0.0036	0.0069	-0.0185	0.273	0.3023
Perceived complexity	-0.0009	0.0010	-0.0240	0.041	0.4204
Stability of CASE toolset	0.0046	0.0412	0.0166	1.676	0.1016
Training and human resources development	0.0036	0.0184	-0.0068	0.731	0.1990
In-house vendor support	-0.0010	0.0006	-0.0251	0.022	0.4411
On-line vendor support	0.0009	0.0007	-0.0249	0.027	0.4357
Environmental scanning	0.0082	0.0609	0.0362	2.465	0.0624
Job/role rotation	0.0167	0.1004	0.0773	4.351	0.0218
Media richness of communication channels	0.0071	0.2116	0.1909	10.201	0.0014
Turnover of (managerial) IS personnel	-0.0103	0.0137	-0.0123	0.527	0.2361
Turnover of (technical) IS personnel	0.0134	0.1402	0.1163	5.869	0.0103

1979; Pierce and Delbecq, 1977; Rogers, 1983). Larger organizations have more slack resources to support innovation (Barreyre; 1978). Some of these slack resources can be directed to investment in CASE technology. Larger organizational also have usually bigger ISD ($r = 0.55$), probably because more systems development works need to be performed to satisfy the requirements of a bigger constituency. Large ISDs can draw on their slack resources and specialized skills of IS personnel to support innovation efforts (Fuller and Swanson, 1992; Nilakanta and Scamell, 1990). Although both organizational size and ISD size are significantly related to adoption, ISD seems to explain more variance ($r^2 = 0.1951$) in adoption than organizational size ($r^2 = 0.1450$). Neither organizational size nor ISD size is significantly related to infusion (Table 5-22b). Number of active projects in the ISD and proportion of development projects are also not significantly related to either adoption (Table 5-22a) or infusion (Table 5-22b).

None of the characteristics of IS personnel -- prior experience of IS personnel, career orientation compatibility of IS personnel, and multiskilled IS personnel was found significantly related to either adoption or infusion.

Three technological characteristics -- perceived capability ($p < 0.05$), perceived efficiency ($p < 0.05$), and stability of CASE toolset ($p < 0.05$) were found significantly related to adoption. However, only perceived capability ($p < 0.05$) was found significantly related to infusion. As indicated before, organizations which perceived capability of CASE tools ($r^2 = 0.1513$) as high in solving systems development problems probably went ahead and invested in CASE. It seems that these organizations also perceived that CASE technology would help them do systems development more efficiently ($r^2 = 0.1412$). Stability of CASE toolset was also an important factor in persuading the organizations to adopt it ($r^2 = 0.1327$). However, adopters did not seem to be bothered by the complexity of CASE tools, again pointing to the possibility that they might have enough in-house expertise, or were willing to climb required learning curves. Once CASE is adopted, only perceived capability of CASE in solving systems development problems, however, seemed to help it infuse it in the organization.

Four leaning variables -- environmental scanning ($p < 0.01$), job/role rotation of IS personnel ($p < 0.01$), media richness of communication channels ($p < 0.001$), and turnover of technical IS personnel ($p < 0.01$) are significantly related to adoption, while three --job/role rotation of IS personnel ($p < 0.05$), media richness of communication channels ($p < 0.01$), and turnover of technical IS personnel ($p < 0.01$) are significantly related to infusion. It seems that media richness of communication channels plays a very important role both in adoption ($r^2 = 0.4384$) and infusion (($r^2 = 0.2116$) of CASE. It is likely that organizations which use richer media to communicate the merits of CASE in systems development work are able to forge a better understanding among IS personnel about its benevolent effects. Such an understanding seems to facilitate adoption, and later, infusion of CASE.

Job/role rotation also seems to facilitate both adoption ($r^2 = 0.2444$) and infusion ($r^2 = 0.1004$) of CASE. IS personnel rotated among many jobs and roles are likely to gain better understanding of the use of CASE and be more appreciative of the viewpoints of different functional areas, leading to a better sharing of knowledge about CASE throughout the organization, and hence adoption and later infusion of CASE.

Turnover of technical IS personnel also seems to be important to both adoption ($r^2 = 0.2182$) and infusion ($r^2 = 0.1402$). When these IS personnel leave the organization, it seems that most of the resistance to CASE adoption goes away with them, thus clearing the way for CASE adoption. Since technically oriented IS personnel have limited understanding of the linkage between IT and business, they may not appreciate the benefits CASE brings to the organization even after it has been adopted. They are likely to continue in their efforts not to use CASE and take its full benefit. Thus the loss of these people in the form of turnover seems to help organizations in a positive way even in infusion.

Environmental scanning has been found significant in past studies in the adoption of an innovation, and not surprisingly that it is significantly related to CASE adoption ($r^2 = 0.1643$, $p < 0.01$). Environmental scanning is likely to make an organization aware of the merits of CASE in addressing systems development problems and its use by competitors for this purpose, and may make the organization more inclined to adopt CASE. However, once CASE is adopted, environmental scanning does little to help infusion (Table 5-22b, $p > 0.05$), emphasizing that even if an organization is aware of the ways in which CASE is being used by its competitors to its full potential in solving system development tasks, their direct imitation is unlikely to work. The ways and means to fully exploit CASE need to be developed inside the organization which needs to take into account its present routines and procedures and how these routines and procedures can be modified to take full advantage of CASE (organizational learning).

Training and human resources development and turnover of managerial IS personnel were not found significant for either adoption or infusion of CASE.

Support of mediating organizations is also not significantly related to either adoption or infusion. It is quite likely that most of the organizations who adopt CASE have already sufficient in-house expertise available and do not need vendor help. This is contrary to the finding of Attewell (1992). However, our operationalization of support of mediating institution captured only some of the many aspects of mediating organizations' roles in the diffusion process. Future studies should examine this construct more closely.

Similarly, turnover of managerially oriented IS personnel is not significantly related to either adoption or infusion. It is also important to keep in mind that this variable was operationalized using just one item, and may not have captured the domain of the construct.

Table 5-23a and Table 5-23b show the results of WLS regression when all the variables in a group were regressed together on adoption and infusion. The results more or less corroborate the results of simple WLS regression. As before, none of the characteristics of IS personnel was found significant in explaining either adoption or infusion. Of the four technological characteristics, perceived capability and perceived efficiency were found significant in explaining adoption, none was found significant in explaining infusion. Of the four knowledge acquisition factors, environmental scanning and training and human resources development of IS personnel were significantly related to adoption, while none was found significantly related to infusion. Significant association of training and human resources development of IS personnel with adoption is a deviation from the findings of simple WLS. However, its negative direction is a cause

Table 5-23A. Results of Robust Regression Analysis with Adoption as Dependent Variable

Variable	Parameter Estimate	R-square	Adjusted R-square	F-value (p-value)	Individual p-values (1-tailed)
Prior experience of IS Personnel	-0.0090	0.0513	-0.0350	0.594 (0.6232)	0.1851
Career orientation compatibility of IS personnel	0.0102				0.1395
Multiskilled IS personnel	-0.0035				0.3287
Perceived capability	0.0159	0.3477	0.2686	4.398 (0.0058)	0.0415
Perceived efficiency	0.0189				0.0058
Perceived complexity	-0.0001				0.4941
Stability of CASE toolset	0.0057				0.0769
Training and human resources development	-0.0126	0.2267	0.1408	2.638 (0.0497)	0.0378
In-house vendor support	0.0102				0.1202
On-line vendor support	-0.0003				0.4817
Environmental scanning	0.0244				0.0035
Job/role rotation	0.0285	0.2444	0.2229	11.324 (0.0019)	0.0010
Media richness of communication channels	0.0133	0.4348	0.4203	29.999 (0.0001)	0.0000
Turnover of (managerial) IS personnel	-0.0177	0.2307	0.1879	5.397 (0.0089)	0.1439
Turnover of (technical) IS personnel	0.0212				0.0013

Table 5-24b. Results of Robust Regression Analysis with Infusion as Dependent Variable

Variable	Parameter Estimate	R-square	Adjusted R-square	F-value (p-value)	Individual p-values (1-tailed)
Prior experience of IS Personnel	-0.0038	0.0296	-0.0490	0.377 (0.7702)	0.3237
Career orientation compatibility of IS personnel	0.0070				0.2014
Multiskilled IS personnel	-0.0043				0.2615
Perceived capability	0.0127	0.1006	0.0007	1.007 (0.4169)	0.0805
Perceived efficiency	0.0001				0.4925
Perceived complexity	-0.0026				0.2805
Stability of CASE toolset	0.0029				0.2259
Training and human resources development	-0.0022	0.0907	-0.0163	0.848 (0.5049)	0.3550
In-house vendor support	-0.0007				0.4609
On-line vendor support	-0.0008				0.4422
Environmental scanning	0.0118				0.0651
Job/role rotation	0.0167	0.1004	0.0773	4.351 (0.0436)	0.0218
Media richness of communication channels	0.0071	0.2116	0.1909	10.201 (0.0028)	0.0014
Turnover of (managerial) IS personnel	-0.0173	0.1778	0.1309	3.785 (0.0325)	0.1069
Turnover of (technical) IS personnel	0.0156				0.0052

of concern. Traditionally, training and human resources development of IS personnel has been found to facilitate the diffusion process, and not inhibit it.

Of the remaining learning variables, as before job/role rotation, media richness of communication channels, and turnover of technical IS personnel were found significantly related to both adoption and infusion, while turnover of managerial IS personnel was not found significantly related to either.

CHAPTER VI
CONCLUSIONS

This chapter provides a summary of the results of this study and discusses its contributions and shortcomings. It also suggests directions for future research.

6.1 Summary of Results

This study profiles different groups of organizations ("adopters", "considered", "non-adopters", etc.) using demographic variables and technological characteristics of CASE. It identifies variables from communications and organizational learning perspectives that are of importance to adoption and infusion of CASE.

6.1.1 Group Profiles

MANOVA and discriminant analysis showed that ISD size is an important variable in differentiating among "adopters", "considered", and "not considered", between "adopter" and "non-adopters", and between "considered" and "not considered". "Adopters" have larger ISDs than "considered" who in turn have larger ISDs than "not considered". Larger size of an ISD usually indicates it has more resources to expend on systems development. Some of these resources can be directed to CASE. Organizational size was also found to be an important variable in differentiating among these groups. "Adopters" have higher annual sales revenue than "considered" who in turn have higher annual sales revenue than "not considered". Organizational size is also an indication of availability of resources. Larger the organization, the more resources it has, and the more resources it can expend on the systems development works. Not surprisingly, larger organizational size is also associated with larger ISD ($r = 0.55$, $p < 0.001$). However, stepdown MANOVA showed that if the effect of ISD is discounted, organizational size is no more significant in differentiating between different groups. There is indication (stepdown MANOVA) that "adopters" perceive the capability of CASE to be greater in addressing systems development problems than "considered", and that is probably why they adopt CASE. However, the result of stepdown MANOVA is not corroborated by discriminant analysis. Small sample sizes (for "adopters", N = 46; for "considered", N = 59) and missing data on many cases may be probable causes for such results.

6.1.2 Predictor Variables of Adoption and Infusion

Robust regression analyses showed that two demographic variables, organizational size and ISD size, are significantly related to adoption. Since larger organizational size and ISD size are associated with more resources, and adoption is that stage of diffusion wherein a decision is made to invest resources necessary to accommodate the implementation of an innovation, it makes intuitive sense that both organizational size and ISD size are related to adoption. However, neither organizational size nor ISD size is significantly related to infusion as resource commitment may no longer be important to infusion where an innovation is to be used to its fullest potential and increased organizational effectiveness is to be obtained by using the innovation in a more comprehensive and integrated. To infuse an innovation, changes in organizational routines and procedures to use the innovation, which involves organizational learning, may be more important.

Analyses also showed that technological characteristic variables are important in explaining variance of adoption. Specifically, perceived capability, perceived efficiency, and stability of CASE toolset, are significantly related to adoption. This is an indication that characteristics of the innovation itself are very important considerations in organizations' decision making process to adopt the innovation. However, only perceived capability was found to be significantly related to infusion, indicating that favorable technological characteristics of an innovation do not ensure that the innovation will be used in a more comprehensive and integrated manner and its full potential will be exploited. Changes in organizational routines and procedures to use the innovation, again, may be more important in infusing an innovation.

Robust regression analyses strongly support the expected role of organizational learning related variables in the diffusion process. Specifically the turnover of technical IS personnel, environmental scanning, job/role rotation, media richness of communication channels, are significantly related to adoption, while turnover of technical IS personnel, job/role rotation, media richness of communication channels, are significantly related to infusion. Media richness of communication channels significantly explained more variance of both adoption and infusion than any other variable. This indicates that how knowledge about benefits of CASE is disseminated is very important in its adoption, while how CASE can be used in an integrated and comprehensive manner is very important in its infusion.

Surprisingly, none of the characteristics of IS personnel related variables was found significantly related to either adoption or infusion. This indicates that individual characteristics and hence individual learning may be less important than organizational learning in having a direct effect on adoption and infusion.

6.2 Hypotheses Supported

Table 6-1 shows results of hypothesis testing. Out of 30 hypothesis postulated 16 were supported. More importantly, it shows that leaning variables play an important role in both adoption and infusion of CASE. In fact, besides perceived capability, learning variables are the only variables found significantly related to infusion, while adoption is also significantly related to both demographic and technological characteristics variables. This indicates that while allocation of resources and technological characteristics of CASE are important in its adoption, organization learning is important in its infusion.

Results also support the direction of relation (positive and negative) for all the hypotheses except for the hypotheses 1-2 and 9-10. These hypotheses postulate relationship of prior experience of IS personnel and multiskilled IS personnel with adoption and infusion. These hypotheses were not found significant, however, parameter estimates (beta coefficients) for these relationships showed that these relationships may have opposite directions from those postulated. Such an outcome is certainly a cause of concern, and future research should look into these relationships more closely.

6.3 Contributions of This Study

The demand of software continues to grow as many more organizations come to use IT to conduct their business. At the same time the shortage of qualified software

Table 6-1: Results of Hypothesis Testing

Independent Variables	Hypothesized Relationship with Dependent Variables		Related Hypotheses
	Adoption	Infusion	
Prior experience of IS professionals	not supported	not supported	Hypothesis 1-2
Career orientation compatibility of IS professionals	not supported	not supported	Hypothesis 3-4
Multiskilled IS personnel	supported	not supported	Hypothesis 9-10
Perceived capability of CASE	supported	supported	Hypothesis 11a-11b
Perceived efficiency of CASE	supported	not supported	Hypothesis 12a-12b
Perceived complexity	not supported	not supported	Hypothesis 13-14
Stability of CASE toolset	supported	supported	Hypothesis 15-16
Training and human resources development	not supported	not supported	Hypothesis 17-18
In-house vendor support	not supported	supported	Hypotheses 19a-19b
On-line vendor support	not supported	supported	Hypothesis 20a-20b
Environment scanning	supported	supported	Hypothesis 21-22
Job/role rotation	supported	supported	Hypothesis 23-24
Media richness of communication channels	supported	supported	Hypothesis 25-26
Turnover of (managerial) IS personnel	not supported	not supported	Hypothesis 5-6
Turnover of (technical) IS personnel	supported	supported	Hypothesis 7-8

developers persists. Thus, it makes good sense to substitute the relatively short-supply of software development labor with capital in the form of CASE technology which has promise to improve productivity and quality problems of software development (Kemerer, 1992). However, in spite of the virtues of CASE technology, organizations have been slow to adopt and implement it. Many organizations that invest in CASE have been seen not to use it. Slow diffusion of such a technology is a cause of concern for both academicians and practitioners. This research contributes to both practice and theory by advancing our understanding of CASE diffusion in organizations in particular and IT innovations in general.

6.3.1 Contributions to Theory

There are few empirical studies which systematically address diffusion of CASE in organizations. Most focus on identifying components of CASE (Wynekoop and Conger, 1991). In the absence of a directing and organizing framework, isolated case studies and anecdotal evidence related to the implementation of CASE tools, mainly in the practitioner literature (for example, Davis, 1983; Kubilus, 1987; Willis, 1983; Zagorski, 1990), have not helped in building a theory or developing guidelines for CASE implementation (Wynekoop, 1991).

This study contributes to the IS literature by identifying gaps in the research on the diffusion of IT innovations in organizations through a systematic in-depth review of the literature within the broader frameworks provided by Kwon and Zmud (1987) and Fichman (1992). The specific contributions of this study are in the organizational adoption and infusion of CASE. This study draws extensively from the innovation, implementation, and organizational learning literatures to build a testable model of CASE diffusion using a survey based approach. The findings of this study should add to already accumulated knowledge about adoption and infusion of other IT innovations. Over a period, such a rich repository of knowledge should allow researchers to compare the roles of different variables in the diffusion of different technologies.

This study supports the assertion that overall locus of an innovation diffusion in organizations is determined by the variables from different perspectives. Variables from both communications perspective (technological characteristics of CASE, specifically capability, efficiency, and stability) and organizational learning perspective (turnover of technical IS personnel, environmental scanning, job/role rotation, and media richness of communication channels) influenced the diffusion of CASE in organizations. The findings also support the assertion that different perspectives may not play equal roles in the different stages of diffusion. While technological characteristics of CASE played a significant role in the adoption of CASE, it did not play any role in the infusion of CASE. On the other hand, organizational learning variables played significant roles in both adoption and infusion stages.

By considering the learning aspects of implementation this study contributes to the IT implementation literature by providing an alternative explanation of why implementation of complex technology such as CASE often fails. It supports the reconceptualization of diffusion of complex organizational innovations proposed by Attewell (1992) that learning has to occur *in situ* and *de novo* for successful implementation. Earlier, it was considered that knowledge associated with successful implementation could be transferred. Recently, Rai (1995) found that learning from external information sources is strongly related to early stages of CASE diffusion.

This study has also developed many new measures and refined some old measures. It has specifically developed measures for prior experience of IS personnel, career orientation of IS personnel, multiskilled IS personnel, turnover of IS personnel, support of mediating institutions, media richness of communication channels, and stability of CASE. It has refined the measures for training and human resources development of IS personnel, environmental scanning, perceived relative advantage, and perceived complexity.

This study also paves the way for future research by identifying significant factors for CASE diffusion in organizations through an empirical test using a national survey. Future research should look into these factors more closely to identify their roles in the diffusion of CASE technology in particular and IT innovations in general.

6.3.2 Contributions to Practice

This research has practical implications for CASE vendors as well as adopter organizations. For CASE vendors, this research has identified the profile of organizations more likely to adopt CASE. These organizations have bigger ISD size, use rich media for communicating knowledge about CASE and how CASE can be used to its full potential, regularly scan their environments for new systems development technologies, regularly rotate their IS employees among different jobs and roles, and perceive capability of CASE to be high in solving systems development problems. This provides a basis for more targeted marketing and promotion, for example, by screening prospects based on how well they fit the profile of an adopter. Targeted marketing is likely to be of particular value for complex organizational innovations such as CASE, because mass media "signaling" of the existence and potential benefits of such technologies is likely to be of lesser importance in promoting their adoption (Attewell, 1992). Even if such promotion does succeed in persuading organizations to adopt that do not fit the adopter profile, they are less likely to sustain diffusion. Organizations which fail at diffusing the innovation may become influential "negative" opinion leaders (Leonard-Barton, 1985). CASE vendors should rather focus on identifying appropriate adopter candidates, learning about the specific problems these organizations face, and taking a more proactive role to promote successful diffusion in these organizations. It is from such learning organizations that vendors are likely to receive useful feedback for product development.

The main implication of this research for adopter organizations is that they should carefully assess the extent to which they fit the profile of an adopter. They should understand that successful diffusion of CASE requires investments in organizational learning which is a long-term process and that not every organization is good at organizational learning (Argyris and Schon, 1978). Considering the risk involved, those that do not fit the profile may seriously consider delaying adoption, or adopting a less complex variant of CASE. Those organizations that do fit the adopter profile and decide to adopt CASE should pursue diffusion strategies that exploit their natural fit.

6.4 Shortcomings of The Study

This study as any other study has some shortcomings and its results should be interpreted and used keeping these shortcomings in mind.

The main limitations of this research arise from the use of cross-sectional survey design with a single key informant. This approach raises some potential issues. Ideally, the values for the predictor variables would be captured immediately prior to the innovation process they are hypothesized to influence, whereas in the current study the variables were captured mid-stream or after the innovation process, depending on where the organization was in the diffusion process. This is typically a problem with much of the empirical work on innovation and involves going back through time to seek possible causes and relationships of the effects on the dependent variables. Many studies consider this methodology as an acceptable compromise for innovation work (Tornatzky and Klein, 1982). It can be argued that many of the model's variables can be assumed to be invariant over the time period during which diffusion occurred. It is, therefore, likely that the values at the time of survey administration are highly correlated with values over the period in which the diffusion of CASE occurred. Hence this may not be a significant limitation for this study. However, the respondents' limited memory recall ability may have lowered the validity of some constructs.

The second concern arises from the use of a single informant. The study utilizes a senior IS executive as the representative of an organization's ISD. It is assumed that these executives have knowledge, are able to make accurate judgements regarding a variety of organizational concepts, and are motivated to respond to survey questions. Some measures may have been inaccurate because the key informant may have been either unmotivated or not very knowledgeable about the domains of construct covered in the survey. Overreporting or underreporting of certain phenomenon may occur as well as a result of the respondent's job satisfaction or personal and role characteristics (Bagozzi, Yi, and Phillips, 1991). The single informant design also precludes the opportunity to strongly confirm the reliability of measures by making comparisons across informants, and increases the potential for a method bias.

Also, there is a concern about time-ordering of effects, that is, levels of the independent variables could have been significantly affected by CASE infusion rather than otherwise.

On the measurement issue, the variables are measured primarily perceptually which leads to the classic problems of anchoring on and bias of Likert-type scales. While validity and reliability of the constructs were performed using the standards methods advocated (Churchill, 1979; Nunnally, 1978; Sethi and King, 1991), further validation using a smaller set of variables and multi-trait-multi-method procedures (Kerlinger, 1986) or confirmatory factor analysis (Bagozzi, Yi, and Phillips, 1991) is warranted. The study also uses a single item to measure turnover of managerial IS personnel. A more elaborate operationalization may have been appropriate.

The sample size used for identifying significant relationships between independent and dependent variables is small. Although the overall response rate is 23.45 percent, the number of organization using CASE is only 46, which is 13.14 percent of all the respondents and 2.95 percent of all the questionnaires sent. This is a cause of concern and the results of this study should be viewed with caution.

6.5 Future Research Directions

This study has made a case for using multiple perspectives for studying diffusion of innovations. However, it tested a model which combined only communications and organizational learning perspectives. Future research may concentrate on using other perspectives to study diffusion of CASE in organizations. Future research may also consider testing a consolidated model involving all the four perspectives discussed in this research. Such models may include those variables which have been found significant in partial models, otherwise there may be too many variables in the consolidated model and testing it empirically may be very difficult, if not impossible.

By focusing on the model proposed in this study, future research may investigate the significance of these relationships using more rigorous methodologies. For instance, investigation of significant relationships is facilitated by consideration of smaller models, multiple participants within each organization, the complementing of questionnaire techniques with interviews, etc. Future research may also study fewer organizations but in greater depth using such rich methodologies such as ethnography and replicated case studies. Fichman (1992) suggests that organizational diffusion of Type II technologies may be too varied, complex, and subtle to be usefully studied with cross-sectional survey methods. Other avenue for future work could be case-based research focusing specifically on adoption and infusion strategies and tactics suggested by organizational learning variables. This kind of process research would provide a natural and valuable complement to the variance model tested here.

While this study focused on the "content" dimension, future studies may examine "process" based dimensions. Rather than using a static cross-sectional approach, examination of the processes using a longitudinal approach will be extremely insightful for revealing the dynamics of the processes involved. Many of the political aspects are not captured by static, rational models such as the one tested in this study. A process based approach may provide additional insight into the how and why of these aspects.

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APPENDICES

APPENDIX A

Table 2-2. Relationship of Communications Variables with Stages of Innovation Diffusion

Independent Variable	Dependent Variable	Study	Association
Job tenure	Adoption	Kimberly and Evanisko (1981); Paolillo and Brown (1979); Rogers and Shoemaker (1971)	positive
	Usage	Lucas (1975, 1976, 1978)	negative
	Performance	Lucas (1975)	mixed
Cosmopolitan	Adoption	Becker (1970); Kimberly and Evanisko (1981); Rogers and Shoemaker (1971)	positive
		Counte and Kimberly (1976); Kimberly and Evanisko (1981)	negative
Professionalism	Adoption	Aiken and Hage (1971); Pierce and Delbecq (1977); Tompson (1969)	positive
	Incorporation	DiMaggio and Powell (1983); Galbraith and Edstrom (1976); Hawley (1968); Rogers and Shoemaker (1971)	positive
Education	Initiation and/or adoption	Becker (1970); Kaplan (1967); Kimberly and Evanisko (1981); Mytinger (1968); Rogers and Shoemaker (1971	positive
	Incorporation	Hawley (1968); DiMaggio and Powell (1983)	positive
	Usage	Lucas (1975, 1976, 1978)	negative
	Performance	Lucas (1975); Taylor (1975)	mixed

Table 2-2. Relationship of Communications Variables with Stages of Innovation Diffusion (continued)

Independent Variable	Dependent Variable	Study	Association
Role involvement	Adoption	Cyert and March (1963); Kimberly and Evanisko (1981); March and Simon (1958)	positive
Elite (top management) values and user participation	Adoption	Baldridge and Burnham (1975); Cox (1967); Hall (1977); Hage and Dewar (1973)	positive
	Acceptance	Davis (1965)	positive
	Adaptation and usage	Gorry and Scott Morton (1971); Neal and Radnor (1973); Mason and Mitroff (1973); Randor and Bean (1973); Robey and Zeller (1978)	positive
User participation	Usage	Zmud (1979)	mixed
Specialization	Adoption	Wilson (1966); Sapolsky (1967); Zaltman, et al. (1973)	negative
	Usage	Robey and Zeller (1978)	negative
	Initiation and adoption	Aiken and Hage (1968, 1971); Kimberly and Evanisko (1981); Moch and Morse (1977); Pierce and Delbecq (1977); Tompson (1969); Sapolsky (1967); Wilson (1966); Zaltman, et al. (1973)	positive

Table 2-2. Relationship of Communications Variables with Stages of Innovation Diffusion (continued)

Independent Variable	Dependent Variable	Study	Association
Centralization	Initiation	Clark (1968); Hage and Aiken (1967); Kaluzny, et al. (1973)	negative
	Adoption and adaptation	Pierce and Delbecq (1977)	negative
	Performance	Dalton, et al. (1980)	negative
	Adoption	Corwin (1970); Kimberly and Evanisko (1981); Rowe and Boise (1974); Zaltman, et al. (1973); Zmud (1982a)	positive
	Usage	Robey and Zeller (1978); Zmud (1982a)	positive
Formalization	Initiation	Pierce and Delbecq (1977); Thompson (1967)	positive
		Duncan (1974); Evan and Black (1967); Hage (1965); Hage and Aiken (1967, 1970); Kaluzny, et al. (1973); Zmud (1982a)	negative
	Adoption	Kimberly and Evanisko (1981); Moch and Morse (1977); Pierce and Delbecq (1977); Rowe and Boise (1974); Zmud (1982a)	positive
	Adaptation	Pierce and Delbecq (1977)	positive
	Usage	Neal and Randor (1973); Randor and Bean (1973); Robey and Zeller (1978); Zmud (1982a)	positive

Table 2-2. Relationship of Communications Variables with Stages of Innovation Diffusion (continued)

Independent Variable	Dependent Variable	Study	Association
Communications link	Initiation	Allen (1967); Tushman (1977)	positive
	Adoption	Becker (1970); Menzel (1966)	positive
	Adaptation	Ebadi and Utterback (1984)	positive
	Adoption	Nilakanta and Scamell (1990); Zmud (1983b)	positive
Compatibility	Adoption	Barnett (1953); Ettlie and Vellenga (1979)	positive
		Fliegel and Kivlin (1966); Carlson (1965)	negative
	Adaptation	Barnett (1953); Ettlie and Vellenga (1979)	positive
		Fliegel and Kivlin (1966); Carlson (1965)	negative
Relative Advantage	Adoption	Ettlie and Vellenga (1979); Petrini (1966); Mansfield (1961, 1968); Singh (1966)	positive
	Adaptation	Ettlie and Vellenga (1979); Petrini (1966); Mansfield (1961, 1968); Singh (1966)	positive
Complexity	Adoption	Graham (1956); Fliegel and Kivlin (1966); Singh (1966)	negative
	Adaptation	Graham (1956); Fliegel and Kivlin (1966); Singh (1966)	negative

Table 2-2. Relationship of Communications Variables with Stages of Innovation Diffusion (continued)

Independent Variable	Dependent Variable	Study	Association
Task Uncertainty	Initiation	Blandin and Brown (1977); Culnan (1983); Ricketts (1982)	positive
	Usage	Blandin and Brown (1977); Culnan (1983); Ricketts (1982)	positive
	Implementation	Thompson (1967)	negative
Autonomy	Satisfaction	Hackman and Oldham (1976); Umstot, et al. (1976)	positive
Responsibility	Satisfaction	Hackman and Oldham (1976); Umstot, et al. (1976)	positive
	Performance	Griffin, et al. (1981)	positive
Variety	Adoption	Quinn (1973)	positive
	Adaptation	Quinn (1973)	positive
	Usage	Quinn (1973)	positive
	Performance	Griffin, et al. (1981)	positive
Heterogeneity	Innovativeness	Baldridge and Burnman (1975); DiMaggio and Powell (1983); Hawley (1968); Heydebrand (1973)	positive

Table 2-2. Relationship of Communications Variables with Stages of Innovation Diffusion (continued)

Independent Variable	Dependent Variable	Study	Association
Uncertainty	Adoption	Cyert and March (1963); DiMaggio and Powell (1983); Hawley (1968); Mohr (1969); Palumbo (1969); Pierce and Delbecq (1977); Schroeder and Benbasat (1975); Van de Ven and Ferry (1980)	positive
		Lawrence and Lorsch (1967); Thompson (1967)	negative
Competition	Adoption	Kimberly and Evanisko (1981); Utterback (1974)	positive
Concentration/ Dispersion	Adoption	Pfeffer and Salancik (1978)	positive
	Incorporation	Thompson (1967)	positive
Inter-organizational Dependence	Initiation	Pierce and Delbecq (1977)	positive
	Adoption	Aiken and Hage (1968, 1971); Becker (1970); Pugh, et al. (1968, 1969)	positive
	Adaptation	Pierce and Delbecq (1977)	positive
	Diffusion	Clark (1965); DiMaggio and Powell (1983); Hawley (1968)	positive

Table 2-3. A Summary of IS Innovation Diffusion Research

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Rai (1995)	ISD-Organizational Interface (top management support, environmental instability, ISD size, performance gap) Innovation triggers (CASE champions, external information sources) organizational support (training availability, job/role rotation, venture groups)	CASE innovation uptake (CASE tool usage, methodology expertise) in US organizations	Survey questionnaires from 405 IS executives in US organizations	Using path-analysis, partial support was found for interrelationship between ISD-organizational interface, CASE innovation triggers, CASE innovation support and actual CASE innovation behavior.	CASE technology	Organization
Rai (1995b)			Survey questionnaires from 405 IS executives in US organizations		CASE technology	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Finlay and Mitchell (1994)	Introduction of IE Experience with IE	Productivity improvements, reduction in systems delivery times, improvements in systems quality, customer perception of improvements, developer involvement in business, customer involvement in systems development process, developer understanding of business, customer understanding of systems development process, developer's perception of skill requirements, developer perception of effectiveness	Survey questionnaires from 26 customers and 52 developers and ten follow-up interviews with respondents	Using a function point count, 85% improvement in productivity and 70% decrease in delivery time were reported. System quality for IE-application was significantly higher than non-IE applications. Both customers and developers had a reasonable view of productivity and quality improvements. Both customer and developer understanding and involvement were thought to have been achieved to an acceptable level. The perceived change in skill requirements varied from planning to development to implementation. Overall, IE had a positive impact on developer effectiveness and increased developers' job interest. Technically oriented developers are threatened by IE was disconfirmed. Cultural change, internal technical support, toolset stability, management commitment, and availability of multi-skilled individuals were found important for successful use of IE.	CASE technology	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Premkumar, Ramamurthy, and Nilakanta (1994)	Innovation characteristics (complexity, technical and organizational compatibility, costs, relative advantage, and communicability) Elapsed time	Attributes of diffusion (adaptation, internal diffusion, external diffusion, and implementation success)	Field survey of two senior executives (one from IS and other from sales/purchase function) from 201 organizations in the US which had implemented EDI	Relative advantage, costs, and technical compatibility were found to be strong predictors of adaptation. While relative advantage and duration were important predictors of internal diffusion, technical compatibility and duration were found to be important predictors of external diffusion. Both forms of compatibility and costs were found to be important predictors of implementation success of EDI.	Electronic data interchang e	Organization
Rai and Howard (1994)	Organizational environment (threat to ISD survival) User characteristics (methodology expertise) Organizational processes (CASE technical support, CASE champions, top management support for IT) Task characteristics (job/role rotation)	CASE tool usage in ISDs of US organizations	Survey questionnaires from 307 IS executives in US organizations	All variables were found to be significantly related to CASE usage in organizations.	CASE tools	Organization
Straub (1994)	Phase I: Social presence and information richness of medium Phase II: Perceived usefulness, ease-of-use Phase III: media use	Diffusion (Phase I: Perceived usefulness Phase II: Media use Phase III: Productivity *benefits) of Email* and Fax in Japanese and US firms	Field interviews, questionnaires, and policy capturing in four large Japanese and US firms *involving* 209 Japanese and 711 US workers	Cultural differences (uncertainty avoidance and complex written language symbols) were found to explain between the difference in *predisposition toward and* selection of electronic communications media in US and Japan.	Email, Fax	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Bretschneider and Wittmer (1993)	Existing investment in computer technology Previous experience with computing Slack resources Extent of bureaucracy and red tape Size Sector State	Adoption of microcomputer technology by organizations	Survey questionnaires from 1005 (622 public and 383 private) sector data processing organizations in the US	Confirmed that after controlling for other factors such as organizational size, experience with computer technology, current investment in computer technology, procurement practices, and task environment of the organization, the sector an organization operates within has differential effect on adoption of microcomputer technology (public organizations have more microcomputers per employee than private organizations)	Microcom puter technology	Organization
Mansfield (1993)	Proportion of industry members using FMS Average rate of return Years of use of FMS	Diffusion of flexible manufacturing systems in Japan, Europe, and the United States	Using questionnaire, detailed data were obtained from 78 firms (17 Japanese, 15 US and 46 West European) using FMS and 97 firms (11 Japanese, 24 US and 62 West European).	Users of FMS are much larger firms than non-user and perceive FMS to be much more profitable than nonusers (requiring higher minimum rate of return).	FMS	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Grover (1993)	Organizational factors (structure -- centralization, formalization, integration, size; IS related -- strategic planning, implementation planning, infrastructure) Policy factors (environmental interaction -- technology policy, customer interaction, competitor scanning,; competitive strategy -- generic strategy, role of It; management risk position) Environmental factors (Industry -- maturity, competition, information intensity, adaptable innovations; customer -- power, vertical coordination) Support factors (top management support, championship) IOS factors (compatibility, relative advantage, complexity)	Decision to adopt a CIOS	Survey questionnaires from 216 senior IS executives of US firms	The support factors and IOS factors (compatibility and complexity) were found most significantly related to adoption decision. Environmental factors were found to be the weakest predictors. The composite model showed that a proactive technological orientation and an internal push for the system were the two most significant sets of facilitators.	Customer-based informatio n systems	Organization
Grover and Goslar (1993)	Environmental uncertainty Organizational factors (size, centralization, formalization) IS maturity IS factors (IT business role and contribution, IT dispersion)	Initiation, adoption, and implementation of telecommunications technologies in organizations	Survey questionnaires from senior executives of 154 organizations in the US.	Environmental uncertainty and decentralization of decision-making were found significantly related to the usage of telecommunications technologies.	15 telecommu nications technologi es	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Orlikowski (1993)	Study of adoption and use of CASE tools in organizations with no hypothesized independent variables		Grounded theory approach (unstructured and semi-structured interviewing, documentation review, and observation) in two organizations	The social context of systems development, the intentions and actions of key players, and the implementation process followed by the organizations are important considerations to account for the outcomes associated with CASE tools.	CASE tools	Organization
Rai and Howard (1993)	Structural factors (size, functional differentiation, specialists' knowledge, job/role design) Management support (institutional leadership, CASE champions) Corporate systems delivery (performance gap, role uncertainty of ISD) Management process (environmental scanning, training, justification of CASE)	CASE penetration (aspects acquired, degree of usage) in US organizations	Open-ended interview of 13 senior IS managers from firms in northeastern Ohio region	Two stage (initiation and implementation) model of CASE penetration was supported. The proposed model for CASE innovation process was supported.	CASE technology	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
George, Nunamaker, and Valacich (1992)	Study of innovation process in an organization which adopted and implemented an electronic meeting systems with no hypothesized independent variables		Case study data collected from multiple sources using multiple methods (internal documents, archival records, structured and unstructured interviews, and direct observations)	Role of key, motivated individuals, congruence of the recognition of the need for innovation and the recognition of innovation's ability to provide that need, positive management attitude, management champion, origin of innovation (administrative vs technical), contextual features (professionalism and degree of coupling between administrative and technical cores), promise of the innovation to bring effectiveness and efficiency in the process, and cost of innovation acquisition related to adoption and implementation success	Electronic meeting systems	Organization
Gordon and Gordon (1992)	Study of adoption of distributed database management systems in organizations with no hypothesized independent variables		Semi-structured interviews of 9 senior IT personnel in companies in the New England area with sales revenue of at least $1b	Organizational culture, organizational structure, and top management's attitude toward the new technology qualitatively concluded to be related to the attitudes toward the adoption of DDBMS		Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Grover and Teng (1992)	Demographic characteristics (size, industry) Maturity of organizational IS (IS expenditure, technology level, IS structure, end-user computing, age of IS, size of IS department)	Adoption of DBMS in US organizations	Survey questionnaires from 288 "person responsible for the data management function in the organization" of medium to large US corporations (over $10m in revenues)	IS maturity, size and industry were fond significantly related to DBMS adoption. Adopters of DBMS were found to be operating in a primarily online environment with centralized IS processing and control. Adopters were larger organizations (size) with a number of years of experience with IS (maturity).	DBMS	Organization
Agarwal, et al. (1991)	Study of diffusion of expert systems in organizations with no hypothesized independent variables		Experiences of MIS department of Carrier Corporation in introducing expert system technology to its users	Effective management of the diffusion process, tempering of user enthusiasm to keep expectations realistic, and cost-justification of adoption of the technology found important.	Expert Systems	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Wynekoop (1991)	Perceived characteristics of CASE tools Expectations Organizational communications organizational resources and management commitment	Implementation (acceptance and level of utilization) of CASE tools in organizations	Survey questionnaires from 55 practicing development professionals in seven US organizations	Senior IS management sponsorship and high levels of organizational communication were found significantly related to implementation success at the organization level, but inversely related at individual level. It was concluded that communication and training related to CASE tools are necessary for successful organizational outcomes, but detrimental to individual acceptance and usage if communication is not accurate. Realistic expectations of CASE tool were found to be more critical for successful individual implementation outcomes than a priori perception of tools.	CASE technology	Organization
Brancheau and Wetherbe (1990)	Adopter characteristics (age, education, media exposure, external participation, external orientation, change agent contact, interpersonal communication, business opinion leadership, computer opinion leadership) Communication channel types (mass media or interpersonal) Communication channel sources (external or internal to company)	Adoption of spreadsheet software by individual accounts and managers	Group interviews and detailed survey (questionnaire from 70 finance/accounting department staff in 18 Fortune 1000 firms)	Early adopters are different than later adopters Confirmed sigmoidal distribution of adoption over time (using logistic function, R^2=0.9996) Interpersonal channels of communication were dominant in all phases of adoption decision making. IS department played a minor role in the diffusion process	Spreadshe et software	Individual

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Cooper and Zmud (1990)	Innovative characteristics (task-technology compatibility, technical complexity)	Adoption and infusion of MRP systems within industrial firms	Telephone survey of production managers and staffs of 62 manufacturing facilities in the US	Task-technology compatibility and low manufacturing complexity significantly affect MRP adoption behaviors but not MRP infusion	MRP systems	Organization
Gurbaxani (1990)	Level of previous IT spending Time	Cumulative adoption of BITNET computing network by universities	Quarterly BITNET Network Information Center records and other sources (1981-1988)	Three functions were used: Gompertz, logistic, and exponential. The logistic clearly provided the best fit (R^2=0.996) with significant t-statistics all model parameters	BITNET computing network	Organization
Gurbaxani and Mendelson (1990)	Level of previous IT spending Time	Cumulative adoption of information technology by US firms	Archival data on total IT spending by large US firms from industry publications (1960-1987)	Three price-modified functions were used: Gompertz, logistic, and exponential. Confirmed that exponential (price) terms were significant in all three cases (R^2 from 0.95 to 0.999), implying that a purely behavioral explanation for IT adoption is incomplete	Informatio n Technolog y	Organization
Kwon (1990)	MIS maturity (age, applications, equipment) MIS climate (management support, user involvement, management attitude) Network behaviors (centrality, sources, intensity, link sources, link intensities)	Infusion of information technology within the administrative offices of a southeastern university	Field survey of department heads, "opinion leaders", and "MIS coordinators" for 74 administrative offices	External communication intensity positively correlated with IT infusion for work groups with a favorable MIS climate	Informatio n technology	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Nilakanta and Scamell (1990)	Characteristics (perceived utility, skills to use, etc.) of information sources (books, periodicals, etc.) Characteristics of communication channels (telephone, library, etc.)	Initiation, adoption, and implementation of database requirements analysis and logical design tools by industrial firms	Questionnaires from over 70 lead database designers in 17 Houston area organizations	Hypotheses linking characteristics information sources and communication channels to diffusion not supported (only 12 of 90 regression coefficients significant at p-values ranging from 0.05 to 0.15)	Database requireme nts analysis and design tools	Organization
Rai (1990)	Environmental instability Knowledge of CASE and structured methodologies Advocacy of CASE Size of ISD Communication with external sources Functional differentiation Performance gap of the ISD Risk aversiveness of the corporate culture Training in CASE and structured methodologies Top management support for IS Job stability within ISD	Degree of CASE penetration (degree of CASE sophistication possessed -- depth of penetration and degree of CASE usage -- breadth of penetration) in information systems departments	Survey questionnaires from 405 IS executives in US organizations	Company CASE training availability, advocacy of CASE, size of the ISD, communication with external information sources, performance gap of the ISD and degree of functional differentiation were found to be significantly related to the depth of CASE penetration. Company CASE training availability, advocacy of CASE, size of the ISD, knowledge of structured methodologies, top management support for the IS function and degree of job/role rotation were found to be significantly related to breadth of CASE penetration. Three stage (initiation, adoption, and implementation) of innovation diffusion was supported.	CASE	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Vipond (1990)	Organizational culture *Work group affiliation* Job function	Change in communicative behavior and job attitudes of software developers as a result of introducing CASE in organizations	Field study of two software development groups in a large IS organization. The research included multiple methods of data collection and eight weeks of on-site study over a period of eleven months.	Introduction of CASE was reported to cause a loss of autonomy and provide software developers with fewer opportunities for use of their individual skills (cumulative deskilling). Existing levels of confusion, intergroup conflict, and sense-making attempts within the organization were also heightened as a result of introduction of CASE technology.	CASE	Organization
Davis (1989)	Perceived technological characteristics (perceived usefulness, perceived ease of use)	Study 1: Current use of mainframe productivity software by white-collar workers Study 2: Predicted future use of PC graphics software by MBA students	Study 1: Questionnaire from 112 users within IBM Canada's Development Laboratory Study 2: Questionnaires from 40 students attending a large university	Study 1: Perceived usefulness and ease of use each highly correlated with self-reported current use Study 2: Perceived usefulness and ease of use each highly correlated with self-reported predicted future use *In both studies*, ease of use appears to be a causal antecedent of usefulness, with little direct effect on use	Study 1: Mainframe productivit y software Study 2: PC graphics software	Individual

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Davis, Bargozzi, and Warshaw (1989)	Perceived technology characteristics (perceived usefulness, perceived ease of use) Expectations of salient referents Attitudes Behavioral intentions	Current use and actual future use of a word processing package by MBA students	Two waves of questionnaire (14 weeks apart) from 107 MBA students attending a large Midwestern university	Perceived usefulness and ease of use have a significant direct effect on behavioral intentions, over and above their effect transmitted through the mediating attitude construct Behavioral intention to use is significantly related to actual self reported use	Word processing package	Individual
Gatington and Robertson (1989)	Adopter industry competitive environment (industry concentration, competitive price intensity, demand uncertainty, communication openness) Supply-side competitive environment (vertical coordination, supplier incentives) Organizational/task characteristics (company centralization, selling task complexity) Decision maker information-processing characteristics (preferences for negative information, preference for information homogeneity, exposure to personal information, exposure to impersonal information)	Adoption of laptop computers by firms	Questionnaires from 125 senior sales officers in US companies with more than 200 employees	Adoption is associated with high vertical integration and high supplier incentives in the supply industry, and high industry concentration and low competitive price intensity in the adopter industry Decision maker characteristics (preference for negative information and exposure to personal information sources) predict adoption	Laptop computers	Organization
Huff and Munro (1989)	Perceived technology characteristics (relative advantage, compatibility, complexity, trialability, observability)	Adoption of microcomputers by individuals	Personal interviews with several dozen microcomputer users	Anecdotal confirmation that microcomputers diffused quickly because of favorable perceived characteristics	Microcom puters	Individuals

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Zmud, Boynton, and Jacobs (1989)	IT management processes (various planning and management process such as IBM's BSP) IT-client interactions (IS manger knowledge of business unit, business manager knowledge of IT)	Penetration of information technology within industrial firms	Questionnaires from IT managers in 132 large organizations and 44 managers in a single high technology firm	Strongly confirmed that IT-related managerial interactions dominate IT management processes in predicting IT penetration; weakly confirmed that a combination of IT-push and user-pull better predicts IT penetration than either variable alone	Informatio n technology	Organization
Leonard-Barton and Deschamps (1988)	Personal characteristics (innovativeness, job-determined importance, subjective importance of task, task related skill, software use skill, sales performance) Managerial influences (perceived management support, management urging)	Adoption of expert systems by individual sales personnel	Telephone survey of 93 salespeople in dozens of sales sites of a multinational computer company	Management was more likely to be viewed achieving "suggested" or "required" use of the system by people rating "low" on all personal characteristics (except use skill)	Expert systems	Individual

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Orlikowski (1988)	Study of role of information technology (CASE technology) in influencing production task control mechanisms, production strategies, and the organization of people around production processes; the influence of social, political, and cultural processes within organizations in shaping the nature and use of information technology with no hypothesized independent variables		Ethnographic methodology in a software consulting firm was used using multiple data collection methods.	The information technology increased the use of unobtrusive control mechanisms, contributed to the routinization and deskilling of systems development tasks, while enhancing their productivity and consistency. The production process became dependent on technical experts responsible for the CASE technology, a shift in power characterized by conflict in project teams. The production strategy underlying systems development became increasingly generalized and standardized, a movement away from professional production processes to bureaucratic ones. The firm culture sustained the acceptance and use of the core information technology. The information technology became an effective medium for facilitating a shared set of meanings among the project members, embedding a "language of systems development" that was an implicit communication protocol, enhancing instrumental action while discouraging reflection on	CASE	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Ball, Dambolena, and Hennessey (1987)	Organizational characteristics (communication effectiveness, number of engineers and scientists in management, etc.) IT group characteristics (stage in Nolan's life-cycle) Information sources (journal, advertisements, salespersons, technical staff, etc.)	Diffusion of database management systems by industrial firms	Questionnaire form 24 members of the Boston Chapter of the Society for Information Management	Organizations with high R&D commitments and a large number of engineers and scientists in management are more likely to be early adopters	Database manageme nt systems	Organization
Brancheau (1987)	Individual differences Organizational Actions Organizational Context	Adoption and utilization of spreadsheet software by individuals in US organizations	Field study and historical analysis (interviews, surveys, and published reports) of data involving 500 professionals in 24 business units of 18 organizations	Classical diffusion theory was supported at the individual level. Earlier adopters of spreadsheet software were younger and more highly educated and more attuned to mass media, more involved in interpersonal communication and more likely to be opinion leaders. The hypothesized differences between opinion leaders and their followers and S-shaped distribution of adoption over time was also supported. At the organizational level, individual-level variables were found to be most reliable predictors of spreadsheet adoption and utilization. The relationship between organizational action and adoption/utilization was not supported.	Spreadshe et software	Individual

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Leonard-Barton (1987)	Innovation characteristics (perceived attributes) Organizational influences (reward systems, formal and informal organizational support, client preferences) Personal characteristics of potential users (demographic descriptors, technical skills, years of experience in the field)	Adoption (use) of structured systems analysis (SSA) by individual system developers	Survey of 145 programmers, analysts, and supervisors in three sites within a natural resources firm	Clients preferences, adopter attitudes, training in SSA strongly discriminate adopters from non-adopters Years of experience, perceived accessibility of consulting, supervisor desires, and acquaintance with an advocate are moderately discriminating		Individual
Raho, Belohav, and Fiedler (1987)	Educational commitment (uncommitted, passive, active, strategic as per McFarlan and McKenny)	Integration of personal computers in US organizations	Survey of 412 companies which were members of Data Processing Management Association	Confirmation of McFarlan and McKenny's four-phase (technology identification and investment, experimentation, learning, and adaptation, rationalization and management, and widespread technology transfer). Phase of diffusion was found significantly related to educational commitment.	Personal Computers	Organization
Zmud (1984)	Need-pull (complexity of project environment) Technology-push (innovation recognition) Management attitudes (receptivity to change, attitude toward MRP)	Adoption of modern software practices by aerospace and federal agencies	Questionnaire from 47 software development managers	Group receptivity towards change impacts technical more than administrative innovations; management support leads to more successful innovation; push-pull theory not confirmed	Modern software practices	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Zmud (1983)	Information channel availability (professional societies, journal subscriptions, internal R&D groups, etc.) Organizational characteristics (size, professionalism, context)	Adoption of modern software practices by aerospace and federal agencies	Questionnaire from 49 software development managers	Confirmed that organizational characteristics mediate the relationship between information channels and adoption of MSP	Modern software practices	Organization
Zmud (1982)	Organizational characteristics (centralization, formalization, structural overlays) Innovation characteristics (administrative versus technical, compatible versus incompatible)	Initiation, adoption, and implementation of modern software practices by aerospace firms and federal agencies	Questionnaire from 49 software development managers	Centralization positively associated with initiation of compatible administrative innovations Formalization positively associated with adoption of incompatible technical innovations	Modern software practices	Organization

Table 2-3. A Summary of IS Innovation Diffusion Research (continued)

Study	Independent Variables	Dependent Variables	Methodology	Major Findings	Innovation Studied	Unit of Analysis
Eveland, Rogers, and Klepper (1977)	Characteristics of regional agency Region Contact with census bureau	Adoption, use, and implementation of GBF/DIME by regional agencies of the US government	Phase I: Survey questionnaires from 257 regional agencies Phase II: "Tracer" study in eight regions	Innovation's adoption, use, and implementation could not be explained from survey data. However, five-stage model (agenda-setting, matching, redefining, structuring, and interconnecting) of innovation was found using "tracer" study, which emphasized gradual specification of operational detail. The specification process was concluded to be influenced by seven conceptual variables: system-support structure, professionalism, innovativeness, external accountability, resources, communication, and effectiveness feedback.	GBF/ DIME	Organization

Table 2-7. A Summary of Organizational Learning Factors

Factors	Lower Level variables	References
Knowledge Acquisition	R&D activities	Huber, 1991
	Level of spending on Research and Development	Cohen and Levinthal, 1989; Mowery, 1981
	Size and focus of R&D budgets	Dodgson, 1993b
	R&D contracts	Ciborra, 1991; Dodgson, 1993b
	Training and education	Huber, 1991
	Level of spending on training and human resource development	Dore, 1973; Dore and Sako, 1989; Sako, 1992; Dodgson, 1992b
	Level of spending on education and training	Dodgson, 1993; Levitt and March, 1988
	Customer and user feedback	von Hippel, 1988; Stinchcombe, 1990; Rosenberg, 1980, 1982
	Customer surveys	Huber, 1991
	"Learning by doing"	Arrow (1962)
	"Learning by using"	Rosenberg, 1976
	Cumulative experience	Argote, et al., 1987
	Performance reviews	Huber, 1991

Table 2-7. A Summary of Organizational Learning Factors (continued)

Factors	Lower Level variables	References
Knowledge Acquisition	Feedback about outcomes	Huber, 1991
	Performance monitoring	Mintzberg, 1975; Huber, 1991
	Competitor analysis	Huber, 1991
	Information acquisition channels(consultants, trade shows, publications, vendors and suppliers, network of professionals)	Huber, 1991
	Informal information networks	Shrivastava, 1983
	Existing knowledge	Corsini, 1987; Dodgson, 1993; Schein, 1985
	Congenital or prior knowledge	Kimberly, 1979; Schein, 1984; Boeker, 1988, 1989
	Prior experience	Shrivastava, 1983
	Experience with technology	Dutton, Thomas, and Butler, 1984; Mody, 1989; Muth, 1986; Yelle, 1979
	Expertise in established technology	Huber, 1991

Table 2-7. A Summary of Organizational Learning Factors (continued)

Factors	Lower Level variables	References
Knowledge Acquisition	"Competency trap"	Huber, 1991
	Specialization	Cooper and Schendel, 1976; Zucker, 1977
	Imitation or use of other's experience	Argote, Beckman, and Epple, 1990; Levitt and March
	Legitimization and justification pressures	Dunbar, et al., 1982; Dutton and Duncan, 1981; Levitt and March, 1988
	Joint ventures	Ciborra, 1991; Dodgson, 1993b; Lyle, 1988;
	Acquisitions	Levitt and March, 1988
	Mergers	Jemison and Sitkin, 1986a; Levitt and March, 1988
	Strategic alliances	Ciborra, 1991; Dodgson, 1993b
	Organizational networks	Hackanssan, 1987
	Boundary spanners or technological gatekeepers	Michael, 1973
	Boundary spanning personnel or gatekeeper characteristics	Tushman, 1979; Tushman and Katz, 1980; Tushman and Scanlen, 1981

Table 2-7. A Summary of Organizational Learning Factors (continued)

Factors	Lower Level variables	References
Knowledge Acquisition	Search initiation threshold	Mintzberg, Raisinghani, and Theoret, 1976
	Organizational slack	Allen, 1979; Hambrick and Finkelstein, 1987
Information Distribution	Personnel movement	Levitt and March, 1988
	Internal employee transfer or job rotation	Huber, 1991
	Socialization	Levitt and March, 1988
	Member interaction and participation	Argyris, 1983; Peters and Robinson, 1984
	Professionalization	Levitt and March, 1988
	Coordination mechanism	Dodgson, 1993b

Table 2-7. A Summary of Organizational Learning Factors (continued)

Factors	Lower Level variables	References
Information Interpretation	Extent of shared interpretation of new information (uniformity of prior cognitive maps, uniformity of framing of information, media richness, information load, amount of unlearning)	Huber, 1991
	Uniformity of prior cognitive maps	Dearborn and Simon, 1958; Ireland, et al., 1987; Kennedy, 1983; Walker, 1985
	Uniformity of framing of information	Dutton and Jackson, 1987; Tversky and Kahanman, 1985
	Media richness (variety of cues that medium can convey, rapidity of feedback)	Huber, 1991
	Information overload	Meier, 1963; Driver and Streufert, 1969; Miller, 1978
	Unlearning (turnover, induction of new members)	Hedberg, 1981; Nystrom and Starbuck, 1984; Klein, 1989
	Turnover	Tunstall, 1983
	Induction of new members	Huber, 1991

Table 2-7. A Summary of Organizational Learning Factors (continued)

Factors	Lower Level variables	References
Organizational Memory	Membership attrition	Huber, 1991
	Information distribution and organizational interpretation of information	Huber, 1991
	Norms and methods for sharing information	Huber, 1991
	Methods for locating and retrieving stored information	Huber, 1991
	Information storage mechanism	Huber, 1991
	Accessibility and utility of information channels	Huber, 1991
	Computer-based organizational memory	Huber, 1991
	Written rules	Levitt and March, 1988
	Oral transitions	Levitt and March, 1988
	Systems of formal and informal apprenticeships	Sproull, et al., 1978

Table 2-7. A Summary of Organizational Learning Factors (continued)

Factors	Lower Level variables	References
Organizational Memory	New organizational members (members of well-organized professions)	Hall, 1968
	Weakness of organizational control (implementation across geography, cultural distances)	Brytting, 1986
	Expert systems for soft information storage	Rao and Lingraj, 1988; Waterman, 1986
	Level of recruitment	Dodgson, 1993
	Organizational ideologies	Dunbar, et al., 1982; Dutton and Duncan, 1981
	Quality of knowledge base	Duncan and Weiss, 1978

APPENDIX B

A National Survey of the Adoption of Computer-Aided Software Engineering (CASE) Technology

If you have any questions or concerns, please contact:

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We Sincerely Appreciate Your Cooperation

CASE (Computer-Aided Software Engineering) is defined as tools and methods to support an engineering approach to software development.

If you have *not considered* using CASE, please respond to Part I only.

Part I

This section pertains to general demographic information.

1. Indicate the organizational unit to which your IS department provides services (please circle one):

   (a) Corporate (b) Division (c) Business Unit (d) Other (specify): ______________

2. Please provide the following information about the organizational unit you indicated in question 1:

   (a) Type of industry the organization is in: ______________________

   (b) Size of the organization (in terms of annual sales): $______________________

3. Please provide the following information about your IS department :

   (a) Number of full-time employees: ______________

   (b) Number of active projects: ______________

   (c) Proportion of projects:

   Development: ________ (%) Maintenance/Enhancement: ________ (%)

4. Please provide the following information about yourself:

   Current job title: ______________________ No. of years in this position: __________

If you have *not considered* using CASE, please stop here and return the questionnaire. If you want a summary of the results, please include your name and address in the space provided on the back of this questionnaire.

If you have considered using CASE, please continue.

1. When did your IS department first evaluate CASE tools? __________ years ago

2. What was the scope of CASE tools considered? (please circle all)

   1. Full life-cycle 2. Front-end 3. Back-end

   4. Other (specify): __________

Part II

Adoption *is defined to occur when a decision has been made to use CASE tools.*

Before your IS department decided to adopt or not to adopt CASE, how did you perceive it in comparison to the development methods, tools, and techniques used at that time?

We perceived that it would:

	Strongly Disagree ... Strongly Agree
1. improve the quality of information systems.	1--------2--------3--------4--------5--------6--------7
2. improve control and coordination of different systems development activities.	1--------2--------3--------4--------5--------6--------7
3 increase the IS department's productivity.	1--------2--------3--------4--------5--------6--------7
4 help the IS department better meet customer needs.	1--------2--------3--------4--------5--------6--------7
5. increase standardization of systems development procedures.	1--------2--------3--------4--------5--------6--------7
6 enhance our IS personnel's effectiveness on the job.	1--------2--------3--------4--------5--------6--------7
7 reduce systems development cost.	1--------2--------3--------4--------5--------6--------7
8. be very complex to use.	1--------2--------3--------4--------5--------6--------7
9 decrease systems development time.	1--------2--------3--------4--------5--------6--------7
10 decrease systems backlog in the IS department.	1--------2--------3--------4--------5--------6--------7
11. reduce maintenance cost.	1--------2--------3--------4--------5--------6--------7
12. be cumbersome to use.	1--------2--------3--------4--------5--------6--------7
13. be much harder to use.	1--------2--------3--------4--------5--------6--------7
14. decrease systems delivery time.	1--------2--------3--------4--------5--------6--------7
15. require a lot of mental effort.	1--------2--------3--------4--------5--------6--------7
16. make it easier for our IS personnel to do their job.	1--------2--------3--------4--------5--------6--------7
17. be often frustrating to use.	1--------2--------3--------4--------5--------6--------7

If you have considered using CASE but *have not adopted* it, please stop here and return the questionnaire. If you want a summary of the results, please include your name and address on the back of this questionnaire.

If you have adopted CASE, please respond to the remaining questions.

Part III

This part pertains to the CASE usage by your IS department. Please check the appropriate level of usage for each functionality.

CASE Tool Functionalities	Level of Usage				
	Not used at all	Used on an experimental basis (or in pilot projects)	Used on regular basis by a few people/projects	Used on regular basis by most people/ projects	Used on regular basis by all people/ projects
Representation of objects, relationships, or processes					
Analysis of objects, relationships, or processes					
Automation of planning or design tasks					
Data base code/schema (e.g. IDMS) generation					
Procedural (e.g. COBOL) code generation					
Test data generation					
Analysis of program structure					
Automatic restructuring of program code					
Analysis of data base structure					
Enforcement of rules, policies, or priorities governing activities of the systems development process					
Resource management: budgeting, scheduling, and tracking					
Access control: auditing, configuration control, and authorization management					
Messaging and electronic communication					
Attaching notes electronically to objects					
Group interaction support (brainstorming, nominal group techniques, etc)					
On-line help for specified commands/features					
Templates for tutorials/demos					
Explanation facility for recommended actions					
Use of domain knowledge to diagnose user problems and recommend appropriate action					
Standardized structures to represent designs					
Consistency of data definition storage structures					
Project repository					

What is the scope of CASE tools used in your IS department? (please circle all)

1. Full life-cycle
2. Front-end
3. Back-end
4. Other (specify): ____________

Part IV

Please indicate your response to each statement.

	Strongly Disagree ... Strongly Agree
1. The CASE toolset had many bugs during initial usage.	1--------2--------3--------4--------5--------6--------7
2. When we first started using CASE, we routinely used help lines provided by vendors.	1--------2--------3--------4--------5--------6--------7
3. Our training and human resource development programs are designed to help IS personnel learn about communications and customer-user interactions.	1--------2--------3--------4--------5--------6--------7
4. We did not use the services of vendors and consultants after adoption of CASE.	1--------2--------3--------4--------5--------6--------7
5. In the past, our IS department used the same development methodology as CASE.	1--------2--------3--------4--------5--------6--------7
6. Our IS personnel are involved with limited aspects of systems development.	1--------2--------3--------4--------5--------6--------7
7. We use communication media which allow us to share knowledge about CASE technology across geographical boundaries.	1--------2--------3--------4--------5--------6--------7
8. Before CASE adoption, our IS personnel had experience with a similar methodology as used by CASE.	1--------2--------3--------4--------5--------6--------7
9. After CASE adoption, turnover among IS personnel with a good understanding of the linkage between IT and business has decreased.	1--------2--------3--------4--------5--------6--------7
10. Our CASE toolset crashed many times during initial usage.	1--------2--------3--------4--------5--------6--------7
11. Our IS personnel are involved with multiple phases of systems development (analysis, design, implementation, etc).	1--------2--------3--------4--------5--------6--------7
12. Vendors and consultants helped us in installation, maintenance, repair, and troubleshooting activities.	1--------2--------3--------4--------5--------6--------7
13. We routinely gather opinions from our clients about systems development technology.	1--------2--------3--------4--------5--------6--------7
14. The CASE toolset was stable during initial usage.	1--------2--------3--------4--------5--------6--------7
15. Integration between various phases of the systems development life-cycle was often problematic during initial usage of CASE.	1--------2--------3--------4--------5--------6--------7
16. People seldom change job responsibilities in our IS department.	1--------2--------3--------4--------5--------6--------7

	Strongly Disagree						Strongly Agree
17. After CASE adoption, turnover among systems analysts has increased.	1	2	3	4	5	6	7
18. After CASE adoption, turnover among IS personnel with limited understanding of business has increased.	1	2	3	4	5	6	7
19. When the CASE toolset was first used, frequent changes were needed to make it work.	1	2	3	4	5	6	7
20. Our IS personnel are trained on a continuous basis to use new systems development methodologies.	1	2	3	4	5	6	7
21. Our IS personnel aspire to be IS managers.	1	2	3	4	5	6	7
22. We use communication media which allow us to simultaneously share knowledge about CASE technology with multiple individuals.	1	2	3	4	5	6	7
23. We regularly conduct special market research studies to keep abreast of new and innovative systems development technologies.	1	2	3	4	5	6	7
24. Training and human resource development are central to our IS department's mission.	1	2	3	4	5	6	7
25. When we initially used CASE, vendors and consultants provided us with skilled personnel.	1	2	3	4	5	6	7
26. We use communication media which provide delayed feedback (e.g. electronic mail) to share knowledge about CASE technology.	1	2	3	4	5	6	7
27. Our IS personnel are able to work in multiple phases of systems development.	1	2	3	4	5	6	7
28. Our IS personnel aspire to be in general management.	1	2	3	4	5	6	7
29. Our training and human resource development programs are designed to help IS personnel learn about team work.	1	2	3	4	5	6	7
30. We routinely participate in professional meetings to keep abreast of new systems development products and processes.	1	2	3	4	5	6	7
31. Our IS personnel are trained on a continuous basis to use new systems development tools.	1	2	3	4	5	6	7
32. Vendors and consultants helped us train our IS personnel in the use of CASE tools.	1	2	3	4	5	6	7

	Strongly Disagree ... Strongly Agree
33. IS personnel participate in multiple development tasks in our IS department.	1--------2--------3--------4--------5--------6--------7
34. Our training and human resource development programs are designed to help IS personnel achieve their full potential.	1--------2--------3--------4--------5--------6--------7
35. IS personnel are typically involved with both front- and back-end activities.	1--------2--------3--------4--------5--------6--------7
36. Our IS personnel are able to work in limited aspects of systems development.	1--------2--------3--------4--------5--------6--------7
37. We frequently rotate IS personnel among various positions and job roles.	1--------2--------3--------4--------5--------6--------7
38. We use communication media which allow customized messages to share knowledge about CASE technology.	1--------2--------3--------4--------5--------6--------7
39. When we first started using CASE, we frequently relied on the expertise of vendors and consultants.	1--------2--------3--------4--------5--------6--------7
40. We use communication media which allow high variety (e.g. textual, graphic, numeric, etc) to share knowledge about CASE technology.	1--------2--------3--------4--------5--------6--------7
41. Our training and human resource development programs are designed to assist customers, suppliers, and other stakeholders to learn about systems development tools and methodologies.	1--------2--------3--------4--------5--------6--------7
42. Our IS personnel are managerially (rather than technically) oriented.	1--------2--------3--------4--------5--------6--------7
43. We routinely use help lines provided by vendors.	1--------2--------3--------4--------5--------6--------7
44. We use communication media which allow multiple cues such as body language, tone of voice, etc (e.g. face-to-face discussion and video-conferencing) to share knowledge about CASE technology.	1--------2--------3--------4--------5--------6--------7
45. We actively keep abreast of new systems development products and processes used by our competitors.	1--------2--------3--------4--------5--------6--------7
46. After CASE adoption, turnover among systems designers has increased.	1--------2--------3--------4--------5--------6--------7
47. Vendors and consultants helped us plan for the integration of CASE tools with existing systems.	1--------2--------3--------4--------5--------6--------7
48. We use communication media which provide quick feedback (e.g. face-to-face discussion and video-conferencing) to share knowledge about CASE technology.	1--------2--------3--------4--------5--------6--------7

Thank you for taking the time to complete this survey.

If you want a summary of the results,
please provide your name and address in the space provided below or include your business card.

Name: ______________________________
Last First

Address: ______________________________
Street

____
City State Zip

Email: ______________________________

Would you like to receive a summary of the results:

☐ Electronically? ☐ Via regular mail?

We will get back to you as soon as possible.

APPENDIX C

SIUC HSC FORM A

REQUEST FOR APPROVAL OF RESEARCH ACTIVITIES INVOLVING HUMAN SUBJECTS

This approval is valid for one (1) year from the approval date. Researchers must request a renewal to continue the research after that date. This approval form must be included in all Master's theses/research papers and Doctoral dissertations involving human subjects to be submitted to the Graduate School.

PROJECT TITLE: Diffusion of Computer-Aided Software Engineering (CASE) Technology in Organizations: Complementing The Classical Diffusion Theory With Organization Learning Perspective

CERTIFICATION STATEMENT:

In making this application, I(we) certify that I(we) have read and understand the University's policies and procedures governing research activities involving human subjects, and that I(we) shall comply with the letter and spirit of those policies. I(we) further acknowledge my(our) obligation to (1) accept responsibility for the research described, including work by students under my(our) direction, (2) obtain written approval from the Human Subjects Committee of any changes from the originally approved protocol **BEFORE** making those changes, (3) retain signed informed consent forms, in a secure location separate from the data, for at least **three** years after the completion of the research, and (4) report immediately all adverse effects of the study on the subjects to the Chairperson of the Human Subjects Committee, Carbondale, Illinois, (618) 453-4543, and to the Director of the Office of Research Development and Administration, Southern Illinois University at Carbondale, (618) 453-4531.

Srinarayan Sharma (signature) — 07/07/95

RESEARCHER(S) or PROJECT DIRECTORS — DATE

Please print or type out name below signature

Srinarayan Sharma

Arun Rai (signature) — July 7, 1995

RESEARCHER'S ADVISOR (required for all student projects) — DATE

Please print or type out name below signature

Arun Rai

The request submitted by the above researcher(s) was approved by the SIUC Human Subjects Committee.

Robert C. Radtke (signature) — 7.27.95

CHAIRPERSON, SOUTHERN ILLINOIS UNIVERSITY HUMAN SUBJECTS COMMITTEE — DATE

Southern Illinois University at Carbondale
Carbondale, Illinois 62901-4627

Department of Management
College of Business and Administration
618-453-3307
FAX: 618-453-7835

August 11, 1995

XXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXX

Dear Mr. XXXXXX:

We are university researchers with no product or service to sell. We would, however, like to entice you to fill out the enclosed survey. The objective of our study is to understand why information systems (IS) departments use or do not use CASE. In return, you will quickly receive a summary of our results which will provide you an up-to-date profile of how CASE is being used nationally. This will enable you to compare the nature of CASE use in your IS department with others.

Your name was selected from a mailing list of top IS executives purchased specifically for this project. The credibility of the results that we will return to the IS community depends greatly on the number of completed survey received. It should take three minutes if you do not use CASE and a maximum of 15 minutes if you use CASE. We are enclosing a pack of coffee and invite you to enjoy the coffee while you complete the survey. Non-coffee drinkers, sorry, we just did not have adequate information to identify you and include something else in its place.

Completion and return of this survey is voluntary*. Your cooperation by responding to the questionnaire is, however, critical to the success of our study. We assure you of the strict confidentiality of your responses; only aggregate results will be reported. If you would like to receive a copy of the results, please include a business card or your name and address. Please contact us if you have any questions or concerns.

Sincerely,

S. Sharma
Doctoral Student
Email: gr4601@siucvmb.siu.edu

A. Rai
Faculty Advisor
Email: arunrai@siu.edu

*This project has been reviewed and approved by the SIUC Human Subjects Committee. If you have any questions concerning your rights as a participant, please contact the Office of Research Development and Administration, Southern Illinois University, Carbondale, at (618) 453-4533.

APPENDIX D

SIU

Southern Illinois University at Carbondale
Carbondale, Illinois 62901-4627

Department of Management
College of Business and Administration
618-453-3307
FAX: 618-453-7835

September 9, 1995

XXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXX

Dear Mr.XXXXXX:

I hope you received the survey on "Adoption of Computer-Aided Software Engineering (CASE) Technology" mailed to you sometime back. I have not received a response from you and would appreciate very much if you could spare a few minutes of your time to complete this survey. In case the survey did not reach you, please find enclosed copy for your convenience.

The success of this study depends upon responses from both users and non-users of CASE. It should take about 2-3 minutes to complete the survey if you don't use CASE and about 10-15 minutes if you CASE. The additional time you may spend as a CASE user will significantly enrich the findings of this study and enhance the knowledge you and I may share with others.

As a doctoral student operating with limited means, I have exhausted all available resources -- loans and personal funds on this study. My persistence in trying to entice you to respond to this survey is not completely altruistic. Your response is critical for completion of my dissertation which, in turn, is essential for my graduation. There is altruistic side as well --absence of your response will, without doubt, adversely affect the quality of this study and consequently, what I can share with IS community.

I am again enclosing a pack of coffee and invite you to enjoy the coffee, while hopefully you complete the survey. If you don't drink coffee, please accept my apologies and pass it on to someone who can use it (e.g., your secretary). In either case, I hope you complete the survey. I recognize that your time is extremely important and fully appreciate the personal effort represented by your response.

Sincerely,

S. Sharma
Doctoral Student
Email: gr4601@siucvmb.siu.edu

VITA

Graduate School
Southern Illinois University

Srinarayan Sharma | Date of Birth: January 15, 1968

Village - Bhakharouli, P.O. - Berma, Via - Tamuria, District - Madhubani, Bihar, India

Indian School of Mines, Dhanbad, India Bachelor of Technology, 1988	Mining Engineering
Indian School of Mines, Dhanbad, India Diploma of Indian School of Mines, 1989	Mine Planning & Design
Southern Illinois University at Carbondale Master of Science in Engineering, 1992	Mining Engineering
Southern Illinois University at Carbondale Doctor of Business Administration, 1996	Management Information Systems

Special Honors and Awards:

Valedictorian, DISM, 1989
Union Public Service Commission Fellowship, 1989
Recipient of research grant awards by Pontikes Center for Management of Information

Thesis Title:

Diffusion of Computer-Aided Software Engineering in Organizations: Complementing Classical Diffusion Theory with Organizational Learning Perspective

Major Professor: Arun Rai

Publications:

Samaddar, S., Rai, A., and Sharma, S. Combining OR/MS and Expert Systems for Inventory Management. *International Journal of Computer Applications in Technology*, Vol. 6, Nos. 2/3, 1993, pp. 155-162.