# ADOPTION OF COMPUTER AIDED SOFTWARE ENGINEERING (CASE) TECHNOLOGY: AN INNOVATION ADOPTION PERSPECTIVE

**G. Premkumar**
Iowa State University

**Michael Potter**
Iowa State University

***Abstract***

*This study examines the impact of various organizational and technology characteristics on the adoption of computer aided software engineering (CASE) technology. Based on research in innovation adoption and IS implementation, the study develops a research model comprised of seven factors that are important for the successful adoption of CASE technology. The data for the study were collected through a field survey of IS managers in the midwest area and 90 responses were received. The results of discriminant analysis reveal that of the seven predictor variables, five are important to differentiate adopters from non-adopters. They are the existence of a product champion, strong top management support, lower IS expertise, perception that CASE technology has greater relative advantage over other alternatives, and a conviction of the cost effectiveness of the technology. The results are consistent with findings in innovation adoption literature as well as case studies of many firms' experience on CASE implementation.*

**Keywords:** computer aided software engineering, CASE, innovation adoption, information technology adoption, CASE implementation, CASE adoption, organizational factors in technology adoption.

## Introduction

The dramatic growth in the use of computers has created an unprecedented demand for information systems (IS) in organizations. Users' demand for information and their increased expectations in terms of service and turnaround time have strained the IS department. Users familiar with PC software now demand similar performance levels, user interface quality, and turnaround time from applications using a mainframe. IS staff are under tremendous pressure to improve their software productivity, reduce their applications backlog and better support this environment. Roughly half of the U.S.'s software expenditure is directed toward the development of business systems (Yourdon, 1989) and any small improvement in productivity in this area will mean considerable savings for firms and the industry. Also, with databases spread across multiple hardware and software platforms, it is becoming increasingly important for database administrators to have handy tools to manage this complex environment effectively. Computer aided software engineering (CASE) technology has been hailed as the solution that will provide the IS manager the capability to increase software development productivity, improve systems quality, provide better systems documentation, and thereby reduce the turnaround time on service requests and better serve the users.

CASE is a set of software tools or an environment that supports software engineering methodologies (Norman and Nunnamaker, 1989) and helps in the automation of software development (McLure, 1989). CASE tools vary widely in scope; some are just diagramming tools while others are integrated tools that automate all phases of the system development life cycle (Alavi, 1993). CASE tools facilitate greater standardization of work procedures and adherence to design discipline (Orlikowski, 1989), and thereby improve the system quality (McLure, 1989).

Although CASE tools were marketed with much fanfare, the adoption rate among firms has been rather slow (Rai and Howard, 1993). Researchers and practitioners have questioned the validity of some of the CASE vendor's claims such as increased productivity (Norman and Nunamaker, 1989; Chen, Nunamaker, and Weber, 1989). While some studies have reported improved productivity (Necco, Tsai, and Holgeson, 1989; Statland, 1989), other studies have questioned the claims of productivity improvement (Alavi, 1993). The cost of the software and long learning curve have kept many firms from adopting CASE technology (Yourdon, 1989). As with any change, the introduction of CASE technology is influenced by various social and political dynamics within the organization (Orlikowski, 1989). While some constituents in the IS department favor the use of CASE, there are others who are reluctant to use it and may resist its adoption through covert measures (Kull, 1987; Sumner, 1993).

There have been a few exploratory studies that have attempted to identify the facilitators and inhibitors to use of CASE technology (Alavi, 1993; Everest and Alanis, 1993). A few case studies have examined the introduction and diffusion of CASE technology in organizations (Orlikowski, 1989; Velde, 1992), and an empirical study (Wynekoop, et al., 1992), using a limited set of firms, studied the factors influencing the use of CASE tools; but the small sample sizes limit the generalizability of their findings. There has been no large-scale empirical research to identify the determinants to adoption of CASE technology; this study attempts to fill that gap.

The primary objective of this study is to evaluate the impact of various factors on organizations' decisions to adopt or not adopt CASE technology. Adoption is defined for this study in terms of either using or not using a CASE tool. Since the introduction of CASE technology brings significant changes to the systems development methodology, work practices of IS staff, and IS culture, the adoption of CASE technology can be studied from an innovation adoption perspective. A brief overview of the background literature is presented, followed by our research model, details of empirical data collection procedures, and results of statistical analysis. Finally, the results are discussed, highlighting implications for practitioners and researchers.

## Background

Two broad research streams, innovation adoption/diffusion and IS implementation in the context of CASE tools, can provide insights for this study. They are briefly reviewed below.

A wide body of research literature is available on adoption of innovations (Rogers, 1983). Most of the studies on innovation have used two distinct perspectives for analysis — adoption (or innovativeness) and diffusion (Kimberly, 1981). While studies using the adoption perspective evaluate the characteristics of an organization or society that make it receptive to innovation and change, studies using the diffusion perspective attempt to understand why and how an innovation spreads and what characteristics of the innovation lead to widespread acceptance. Studies have also differentiated between individual adoption and organizational adoption where the decision making could be more complex (Fichman, 1992). Organizational factors such as managerial influence and/or senior management mandate may influence an organization's adoption decision.

The importance of innovation attributes to innovation adoption has been well documented in research literature and the impact of more than 25 innovation attributes on adoption has been studied (Roger, 1983). The meta-analysis of Tornatzky and Klein (1982) suggests that of the 25 attributes, three are found to be consistently significantly related to adoption. They are compatibility, complexity, and relative advantage. Greater *compatibility* of the innovation to existing work practices and value systems has been found to favor adoption (Cooper and Zmud, 1990; Ettlie et al., 1984). *Complexity* of the innovation, in terms of understanding and using the innovation, has been observed to discourage adoption (Cooper and Zmud, 1990; Robertson and Gatignon, 1986). *Relative advantage* or superiority of the innovation to existing artifacts has been found to be consistently positively related to adoption (Tornatzky and Klein, 1982; Premkumar et al., 1994). Beyond mere recognition of an innovation's superiority, evaluation of its suitability within the specific context of the adopting unit's environment is essential.

Researchers have also used alternative terms to represent this variable. *Technology push* and *need pull* are related constructs that represent the advantages of the technological innovation relative to the needs of the organization (Zmud, 1984; Munro and Noori, 1988). Researchers have also found that *higher cost* for an innovation is negatively associated with adoption of that innovation, but it is important to evaluate the costs relative to the benefits that could accrue from the innovation (Zaltman et al., 1973).

In the IS area, researchers are increasingly studying IS implementation in the context of innovation adoption (Cash et al., 1992; Kwon and Zmud, 1987; Fichman, 1992). Kwon and Zmud (1987) developed a framework integrating the classical innovation research and IS implementation research. They identified five broad categories of determinants for IT adoption based on Leavit's (1965) organizational model. They are technological or innovation factors, structural or organizational factors, environmental factors, individual factors, and task factors. The three innovation factors — complexity, compatibility, and relative advantage — and four organizational structural variables — specialization, centralization, formalization, and informal network — were found to be important for adoption. In addition, they identified five environmental variables — heterogeneity, uncertainty, competition, resource concentration, and inter-organizational dependence — and six task variables — task uncertainty, responsibility, autonomy, variety, identity, and feedback — to be important for adoption. For individual level adoption, many individual factors such as job tenure, education, cosmopolitanism, role involvement etc. were found to be relevant for adoption.

In a recent study Grover (1993) found that none of the variables measuring environmental factors were significant in discriminating adopters from non-adopters of inter-organizational systems (IOS). The same study found that while organizational size was a significant factor, other organizational factors (specialization, centralization, formalization) were not important for IT adoption in the context of inter-organizational systems. He also found IS infrastructure or resources, top management support, product champion and strategic IS planning to be more important organizational determinants of IOS adoption. This is consistent with studies on IS implementation where these factors have been found to be more relevant compared to the more traditional variables such as formalization, standardization, and integration that are used in innovation studies.

IS implementation research has found *top management support* to be the most important variable for successful implementation (Zmud, 1984; Sanders and Courtney, 1985; Guimaraes et al., 1992). Mere approval of the project by top management is not sufficient; it must be followed with active commitment and involvement in the project. Studies, both in innovation adoption and IS implementation, have highlighted the role of *product champion* in bringing new technologies to organizations (Beath, 1991; Van de Ven, 1986; Burgleman and Sayles, 1986; Quinn, 1985). Product champions educate the users on the new technologies, evaluate new technologies and their relevance to the organization, and facilitate in the adoption and smooth transition from earlier technology to the new one. IS research has also highlighted the role of *IS expertise* and the availability of necessary IS resources for successful implementation of IS projects (Raymond, 1990; Lehman, 1985). New technologies that require considerable expertise may scare away many firms unless there is an in-house infrastructure to master those complex technologies and exploit their capabilities (Ettlie, 1986; Fichman, 1992; Sumner, 1993).

In the context of CASE technology, there has been no large-scale empirical research on factors influencing the adoption of CASE tools. There have been a few exploratory studies (Sumner, 1993; Alavi, 1993; Everest and Alanis, 1993), case studies (Orlikowski, 1989; 1993), and an empirical study on use of CASE tools (Wynekoop et al., 1992). Sumner (1993) developed an initial five-factor model comprised of organizational, application development, policy, environmental, and support factors. Based on some empirical data, she did not find support for the policy and environmental factors. Some of the important variables identified by her were top management support, user involvement, vendor support, training, perceived benefits, and compatibility. Wynekoop et al., (1992) found perceived relative advantage and management commitment to be important factors influencing the use of CASE tools.

Lack of management support, high price, lack of compatibility, and difficulty to use were cited as critical inhibitors for not adopting CASE technology (Everest and Alanis, 1993). The same survey listed improved system quality, improved communication, reduced IS development and maintenance effort, better documentation, increased discipline and structured methods, and better tracking of user requirements as some of the perceived benefits from using CASE tools. Power struggles and resistance to introduction of CASE tools from within IS department are also cited as problems and were found in case studies of firms adopting CASE technologies (Orlikowski, 1989). Studies have also indicated the importance of a product champion who could educate the senior management about the benefits of CASE technology and facilitate its adoption in an organization (Rai and Howard, 1992). Alavi (1993) stresses the importance of top management support and compatibility of existing work practices with CASE methodology to make it attractive for a potential adopter.

## Research Model and Hypotheses

Based on the literature review, a research model identifying the important determinants of CASE tool adoption was developed. The model is shown in Figure 1.

The research conducted in innovation adoption is vast, encompassing a wide range of variables

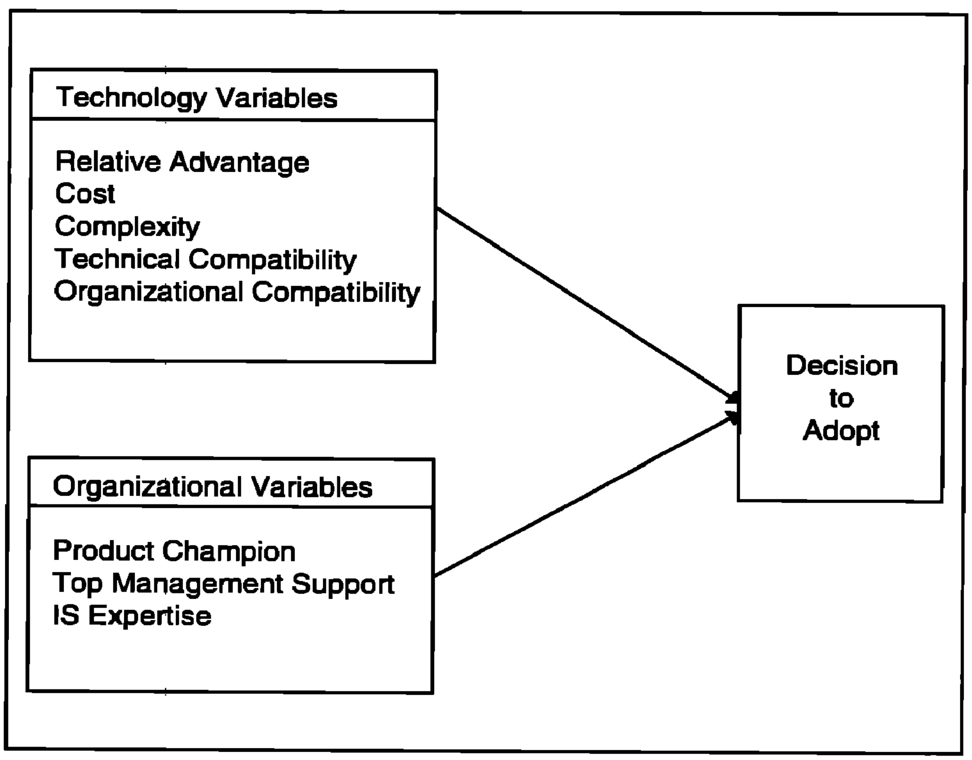


**Figure 1. Research Model**

applied in different contexts in a broad range of disciplines. Any attempt to develop a comprehensive model for innovation adoption results in a very large model that is difficult to validate due to various constraints in empirical studies. Many of the variables identified in this research stream are specific to a particular context and therefore may not be relevant for a general model (Tornatzky and Klein, 1982). It is important to identify variables that are relevant to the technical innovation that is being studied for which exploratory studies in that area provide some guidance. We have attempted to develop a parsimonious model that may best explain the adoption of CASE tools. We do not claim this as a comprehensive model for CASE technology adoption.

Since most studies on adoption of CASE technology consider it as an organizational adoption decision (Sumner, 1993; Orlikowski, 1993), the study did not consider factors predicting individual adoption such as cosmopolitanism, job tenure, etc. Individual factors are more relevant in explaining the diffusion and use of an innovation within an organization after an organizational decision to adopt it. People tend to use the innovation, more or less, depending on various individual characteristics and the fit between the task and technology. Since the study of diffusion or CASE tool usage was outside the scope of this paper, we did not consider individual factors in the research model. Also, task related factors such as task autonomy, task-responsibility, etc. were not considered since there is no empirical evidence to relate these variables to CASE adoption.

Environmental variables were not significant in the adoption of inter-organizational systems (IOS) (Grover, 1993), an innovation that has significant potential for external influences on adoption decision due to various forces from trading partners and other external agencies. If environmental factors have a limited effect on the adoption of IOSs, it can be expected to have less of an effect on the adoption of CASE technology, which is used by an internal department (IS) and is too remote to be influenced by external business forces. Studies on CASE adoption and use have not found environmental factors to be important (Sumner, 1993; Everest and Alanis, 1993). Orlikowski (1993) also does not consider any of the traditional environmental variables (such as uncertainty, resource concentration, etc.) in her model, but considers the availability of the technology. Hence, environmental factors were not considered in the research model.

Since research on IS implementation lays more emphasis on top management support, product champion and IS resources rather than on organizational structural variables such as specialization, centralization, etc., structural variables were not included; and IS implementation variables previously found to be more relevant were included. We also included cost as a technology variable since prior studies on CASE have found it to be a significant inhibitor to adoption (Everest and Alanis, 1993). A brief description of the variables and the research hypotheses are provided below.

## Relative Advantage

Relative Advantage is the degree to which the innovation is perceived to be superior to the idea or artifact it supersedes, and has been posited to be positively related to adoption (Premkumar et al., 1994; Rogers, 1983; Tornatzky and Klein, 1982). Researchers have used other terms such as "technology push" to refer to this variable (Zmud, 1984). Organizations adopt innovations to overcome performance gaps and deficiencies or to exploit new opportunities. CASE technology claims to increase system development productivity and improve system quality; many software developers perceive CASE as the answer to the software crisis that is plaguing the software industry (Martin, 1988; Chikofsky, 1988). The technology also brings a discipline in design and better documentation (Orlikowski, 1989). However, not all firms perceive CASE tools as an answer to their software problems, since other solutions may be better or the IS environment may not be amenable to CASE implementation (Alavi, 1993). Further, there is some doubt that the benefits claimed by CASE vendors materialize. Uncertainty of the benefits (or lack of relative advantage) has been perceived to be higher for non-users of CASE tools compared to CASE users (Sumner, 1993). We can expect that firms that perceive CASE tools as a solution to their performance gaps in software development are more likely to adopt CASE tools. Hence:

**Hypothesis 1:** Firms that perceive greater relative advantage of CASE technology are more likely to adopt it.

## Compatibility

Rogers (1983, p.223) defines compatibility of an innovation as "degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of the potential adopter." Prior studies have found it to be an important variable to explain innovation adoption (Kimberly, 1981; Tornatzky and Klein, 1982) and IT adoption (Cooper and Zmud, 1990; O'Callaghan et al., 1992). Schultz and Slevin (1975) highlight the need for technological innovations (such as IS) to have both organizational and technical validity. While organizational validity evaluates compatibility with existing attitudes, beliefs, and value systems, technical validity evaluates compatibility with existing systems. Adoption of CASE technology may involve changes to system development methodologies, IS culture, IS staff work practices, and perhaps organizational structural hierarchies (Orlikowski, 1989; Yourdon, 1989). These changes could alter the political and social dynamics within the department and can cause resistance to change. In some firms, experienced designers and programmers feel that highly structured tools interfere with their job creativity (Kull, 1987). Sumner (1993) found resistance from system developers and a lack of fit with current methodology to be major barriers for introduction of CASE. Organizations where CASE methodology is compatible with existing development practices are more likely to favor introduction of CASE technology (Alavi, 1993).

It is necessary for a technical innovation to be not only organizationally compatible, but also technically compatible with other interconnected technologies in the organization (Alavi, 1993). In the context of CASE technology, technical compatibility with different software and hardware platforms and other CASE tools existing in an organization is an absolute necessity. Everest and Alanis (1993) found that lack of compatibility was a major barrier for not using CASE technology. Based on available evidence, we can hypothesize:

**Hypothesis 2:** Firms that perceive greater compatibility of CASE technology with their existing IS environment are more likely to adopt it.

## Complexity

Complexity of an innovation is "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers, 1983, p. 230). Although an innovation may appear to be useful, the organization may find it complex to use. Since complexity of an innovation functions as an inhibitor to adoption, it is usually negatively related to adoption (Tornatzky and Klein, 1982). Cooper and Zmud (1990) found that the perceived complexity of material requirement planning (MRP) systems was a significant predictor of adoption. CASE tools have been found to be complex, with unacceptable learning curves (Yourdon, 1989; Sumner, 1993). Everest and Alanis (1993) found "difficulty to use" to be one reason for not using CASE tools. On the other hand, firms that have the necessary infrastructure and do not perceive CASE technology to be complex will have fewer reservations about adopting it. Hence:

**Hypothesis 3:** Firms that perceive CASE technology to be less complex are more likely to adopt it.

## Cost

The less expensive the innovation, the more likely it will be adopted (Rogers, 1983). The cost of an innovation includes both the initial investment cost as well as the operations and training cost that facilitate effective use of the innovation. While *relative advantage* captures increased benefits compared to existing methods, *cost* compares financial investment to the benefits. Cost has been suggested as a major barrier to adoption of CASE tools (Everest and Alanis, 1993). Non-CASE users responded with significantly higher values for *cost* as a barrier to using CASE compared to CASE users (Sumner, 1993). Firms that perceive the cost of CASE technology to be high will have reservations in adopting it. Hence:

**Hypothesis 4:** Firms that perceive CASE technology to be relatively less costly are more likely to adopt it.

### Top Management Support

Top management support has always emerged as an important variable in studies on IS implementation (Lucas, 1978; Guimares, et al., 1992) and IT adoption (Zmud, 1984; Grover, 1993). Active involvement and support of top management provides appropriate strategic vision and direction, besides sending signals about the importance of the innovation. It helps to ensure that adequate resources will be allocated if the innovation is adopted. CASE technology is expensive and benefits from switching over to CASE methodology may not flow in immediately. The decision to adopt CASE technology may be a risky decision for the IS manager unless he or she has a firm commitment from top management to explore the technology. System development productivity, which is a major concern of top management, can be addressed with CASE tools and to that extent may attract the attention of senior management.

CASE technology, perhaps for the first time, provides a formal methodology for integrating business plans in IS planning and subsequent system projects. This is supposed to result in systems that are more responsive to business needs. Normally, in the first phase of a CASE methodology (e.g., information engineering), senior management actively participates in providing long-term directions to the IS department to enable them to develop systems that could generate competitive advantage or those that could effectively support the organization's business plans. The ability to provide such inputs may motivate senior management to support CASE technology (Rai and Howard, 1993). However, in organizations where information technology is not considered to be critical to operations and senior management is not concerned about IS operations, support for CASE technology may be lacking and IS managers may be reluctant to risk making that investment.

Sumner (1993) found that top management commitment was one of the major success factors for adopting CASE tools. Wynekoop et al., (1992) found that management commitment was an important factor influencing the use of CASE tools. Crosslin et al., (1993), in a survey of IS experts, found that top management support is an important factor for successful implementation of CASE technology. Hence:

**Hypothesis 5:** Firms that have significant top management support for CASE technology are more likely to adopt it.

### Product Champion

Champions perform a very critical role in the introduction of new technologies in organizations. Initially, they educate senior management and users on the potential benefits of the technology and create an awareness of the technology and its need in the organization. Marketing of new technological innovations within an organization is very important for successful adoption (Robertson and Gatignon, 1986). The champion also coordinates the various activities related to the acquisition of the technology and ensures adequate resources allocation for adoption and subsequent implementation. Existence of a champion has been found to be an important enabler in the adoption of many new IS technologies (Runge, 1985; Beath, 1991; Grover, 1993). A product champion for CASE technology is a necessity in many organizations to sort out the various claims about the technology and its professed benefits, to foresee the significant changes to work practices and resultant resistance within the IS department and evolve suitable strategies to overcome them, and to justify to senior management the substantial investments in the technology. Hence:

**Hypothesis 6:** Firms that have a champion for CASE technology are more likely to adopt it.

### IS Expertise

Successful innovations cannot take place without an existing technological infrastructure (Madique and Zirger, 1984) and the innovation must be consistent with the firm's capabilities and skills (Burgleman, 1983; Cash et al., 1992). Any new technology has its attendant risks and a firm that has the necessary infrastructure would perceive less risk and therefore be more willing to adopt a new technology. In a software development environment system developers are the primary resources and they should be familiar with the necessary CASE methodologies. Availability of IS expertise in terms of familiarity with structured methodologies, process modelling techniques, and relational databases should create a favorable climate for easy introduction of CASE technology. Hence:

**Hypothesis 7:** Firms that have higher IS expertise are more likely to adopt CASE technology.

## Research Methodology

### Measurement

Multi-item indicators were used for measuring the research variables. The appendix provides a list of items used for the measurement of each construct. Most items were measured using a seven-point Likert-type scale ranging from strongly disagree to strongly agree. A single categorical item was used to determine if the firm was an adopter or a non-adopter of CASE tool based on whether they use a CASE tool. Respondents who claimed to use CASE tools were asked to respond based on conditions that existed just prior to adoption of CASE technology, and the remaining responded based on current conditions.

*Relative advantage* was measured by five items that assessed the respondents' perception of benefits from CASE technology based on well published lists of benefits (Chen, et al., 1989; Sumner, 1993). *Compatibility* was measured using seven items; two items measured technical compatibility with the hardware/software platforms and five items measured the organizational compatibility with culture and methodology, and resistance to the use of CASE tools. Two items were used for measuring *cost* and *top management support*. The level of *IS expertise* was assessed by three items measuring experience with data modelling, process modelling, and structured design and programming methods. Single item measures were used for measuring *complexity* and *product champion*.

### Data Collection

A detailed questionnaire that measures the various research variables was developed and pilot tested with experts in the field. Prior to the development of the research model, a very detailed qualitative research study was conducted (not described in this paper) that involved extensive face-to-face interviews for more than two hours with IS managers and CASE coordinators of eight firms. This research provided a good understanding of the important predictor variables and appropriate items for measuring them. Each construct was measured, wherever possible, with multi-item indicators aimed at tapping the underlying theoretical dimension. The items were derived from extensive literature review and our qualitative research.

An organizational level study was planned with one senior respondent from each firm. The data for the study were collected from a field survey of 315 firms, partially convenience sampled for proximity reasons and budgetary constraints. The survey was administered in one Association of Systems Management meeting with little success. Subsequently, it was administered in a CASE software meeting and also mailed to IS department chiefs from firms in three mid-western states. Ninety responses were received for a response rate of 29%. We feel that the response rate was reasonable, particularly since no follow-up letters were sent due to budgetary constraints. An analysis of respondent's title included on surveys reveal that all were in the managerial cadre, with titles of manager, database administrator, director, etc. Although small, it gives us confidence that the respondents were sufficiently high in the hierarchy to provide an organizational level perspective of CASE tool adoption.

### Sample Characteristics

The characteristics of the sample are shown in Table 1. The respondents were fairly well distributed by sales revenue and IS employee size. Although firms from different industries responded to the survey, there is a bias towards the insurance industry, which is partially due to the geographic location of the survey. There were an equal number of adopters and non-adopters.

| Variable | Number | Frequency |
|---|---|---|
| **1. Sales** | | |
| Small | 25 | 28% |
| Medium | 27 | 30% |
| Large | 19 | 21% |
| Don't Know | 19 | 21% |
| **2. Industry** | | |
| Insurance | 15 | 17% |
| Finance/Banking | 8 | 9% |
| Manufacturing | 21 | 23% |
| Government | 10 | 11% |
| Retail/Wholesale | 4 | 4% |
| Education | 8 | 9% |
| Transportation | 6 | 7% |
| Other | 18 | 20% |
| **3. Type of Tool** | | |
| Lower | 10 | 22% |
| Upper | 3 | 7% |
| Integrated | 32 | 71% |
| **4. Category** | | |
| Adopter | 45 | 50% |
| Non-Adopter | 45 | 50% |

**Table 1. Sample Characteristics**

These values show that although the study used convenience sampling, there is no demographic sampling bias.

## Validity and Reliability of the Constructs

The constructs were tested for various validity and reliability properties. While validity is the degree to which an instrument measures the construct under investigation, reliability measures the stability of the scale based on an assessment of the internal consistency of the items measuring the construct (Churchill, 1979). The basic statistics for the various constructs are given in Table 2.

Construct validity was assessed using convergent and discriminant validity (Nunnally, 1978). While convergent validity measures the extent to which construct measures cluster together, discriminant validity measures the extent to which a construct differs from other constructs and is indicated by a measure not correlating highly with other measures from which it should theoretically differ (Churchill, 1979). Principal component factor analysis was used to test the validity properties. Convergent validity was evaluated by examining if the theorized items converged together on the appropriate single constructs, and discriminant validity was evaluated by examining the cross loading of items on multiple factors. The standard criteria of eigen- values greater than 1.0, factor loadings greater than 0.3, and a well explained factor

| Variable | # of Items | Mean | SD | Alpha |
|---|---|---|---|---|
| Relative Advantage | 5 | 5.01 | 1.26 | 0.85 |
| Cost | 2 | 3.90 | 1.71 | 0.86 |
| Technical Compatibility | 2 | 4.58 | 1.57 | 0.79 |
| Org. Compatibility | 5 | 4.29 | 1.26 | 0.78 |
| Top Management Support | 3 | 4.17 | 1.46 | 0.79 |
| IS Expertise | 3 | 4.15 | 1.46 | 0.85 |
| Product Champion | 1 | 3.69 | 1.97 | - |
| Complexity | 1 | 3.75 | 1.44 | - |

**Table 2. Basic Statistics and Reliability**

structure were used in he analysis (Zeller and Carmines, 1980). The results are shown in Table 3.

| Variable | Item | Factor Loading | Eigen-Value | Variance Explained Ind. | Variance Explained Cum. |
|---|---|---|---|---|---|
| Relative Advantage | | | 6.86 | 29.8 | 29.8 |
| | RA-1 | .82 | | | |
| | RA-2 | .46 | | | |
| | RA-3 | .67 | | | |
| | RA-4 | .61 | | | |
| | RA-5 | .79 | | | |
| | Cost-1 | -.79 | | | |
| | Cost-2 | -.73 | | | |
| Compatibility | | | 3.78 | 16.4 | 46.2 |
| | TechCom-3 | .82 | | | |
| | TechCom-4 | .71 | | | |
| | OrgComp-1 | .72 | | | |
| | OrgComp-2 | .54 | | | |
| | OrgComp-3 | .78 | | | |
| IS Expertise | | | 1.87 | 8.1 | 54.3 |
| | ISExp-1 | .76 | | | |
| | ISExp-2 | .85 | | | |
| | ISExp-3 | .87 | | | |
| Technical Compatibility | | | 1.49 | 6.5 | 60.8 |
| | TechCom-1 | .84 | | | |
| | TechCom-2 | .82 | | | |
| Top Management Support | | | 1.18 | 5.2 | 66.0 |
| | TopMgmt-1 | .61 | | | |
| | TopMgmt-2 | .83 | | | |
| | TopMgmt-3 | .70 | | | |

**Table 3. Validity Table**

It reveals that, except for two variables, compatibility and cost, all other multi-item indicators exhibit adequate convergent validity. The seven items measuring compatibility split into two separate factors measuring technical compatibility and organizational compatibility. The two items measuring cost loaded with the items measuring relative advantage. Since factor analysis typically loads constructs with one or two items to other factors to develop a minimal set of factors, we decided to perform a separate factor analysis on the items measuring cost and relative advantage. The factor analysis revealed that the items loaded on two separate factors as originally theorized. Hence, we decided to use *cost* as a separate construct based on the second factor analysis, which confirmed it as a separate construct. All the other items loaded on appropriate constructs as originally envisioned and the cross loadings with other factors were minimal. Hence, all the multi-item variables can be considered to exhibit adequate discriminant validity.

The reliability of the constructs was assessed using Cronbach's Alpha. The results in Table 2 indicate that all the constructs have adequate Alpha values, and therefore exhibit sufficient reliability.

## Results

The choice of the data analytic technique for testing the research hypotheses was restricted to two options — individual t-tests of differences between adopters and non-adopters for each research variable or a multivariate discriminant analysis that identifies the important research variables that best discriminate between adopters and non-adopters. The multivariate analysis option is a more powerful and accurate statistical procedure to evaluate the relationships of the research variables with the adoption decision. Hence, it was decided to use multi-variate discriminant analysis as the data analytic technique. However, for the purpose of comparative analysis the groupwise means for all the research variables have also been reported. The results of the discriminant analysis are shown in Table 4.

| Wilks' Lambda = 0.4120<br>Chi-Square = 54.97<br>D.F. = 2<br>Sig. = 0.0001 | | | | | | |
|---|---|---|---|---|---|---|
| **Variable** | **Discriminant Coefficients** | **Discriminant Loading** | **Group Mean(S.D.) Non-Adopter** | | **Adopter** | |
| Relative Advantage | 0.204 | 0.655 | 4.16 | (1.33) | 5.76 | (0.74) |
| Cost | -0.838 | -0.965 | 5.32 | (1.27) | 2.67 | (1.02) |
| Product Champion | | 0.374 | 2.67 | (1.47) | 4.66 | (1.81) |
| Top Management Support | | 0.281 | 3.53 | (1.09) | 4.76 | (1.40) |
| IS Expertise | | -0.305 | 4.55 | (1.44) | 3.70 | (1.41) |
| Complexity | | -0.212 | 3.96 | (1.46) | 3.64 | (1.42) |
| Organizational Compatibility | | -0.154 | 4.11 | (1.17) | 4.00 | (1.29) |
| Technical Compatibility | | 0.115 | 4.17 | (1.71) | 4.97 | (1.56) |
| **Classification Accuracy** | **Total** | **Non-Adopter** | **Adopter** | | | |
| Non-Adopter | 37 | 28 (75.7%) | 9 (24.3%) | | | |
| Adopter | 41 | 3 (7.3%) | 38 (92.7%) | | | |
| Overall Accuracy | 84.62% | | | | | |

**Table 4. Discriminant Analysis**

Discriminant analysis involves deriving a linear combination of one or more research variables that will best discriminate between the *a priori* defined groups (Hair et al., 1983). The objective of the analysis is to maximize between-group variance relative to within-group variance. Stepwise variable selection, with the selection criteria of minimizing Wilks Lambda and a tolerance level of 0.001, was used to generate the discriminant function. The value of Wilks Lambda, the Chi-square value, and the level of significance are shown in Table 4. It is significant at $p < 0.001$.

The standardized discriminant coefficients for the variables that are significant at $p < 0.001$ are also given in Table 4. Two of the eight variables have significant discriminant coefficients. They are relative advantage and cost. Discriminant loadings (also known as structure correlations), measuring the simple linear correlation between each predictor variable and the extracted discriminant function, are favored to discriminant coefficients since they are less susceptible to problems of multi-collinearity and sample size (Hair et al., 1983). While there are no rigid rules about the goodness of these values, the general guidelines are that values above 0.25 - 0.30 are satisfactory and acceptable (Lambert and Durand, 1975). The discriminant loadings for all the variables are also provided in Table 4. Five variables — relative advantage, cost, top management support, champion, and IS expertise — were found to have discriminant loadings above the cut-off value. Mean and standard deviation values for the variables in the adopter and non-adopter groups are also given in Table 4 for a better understanding of the results of discriminant analysis.

Another important test is to examine the ability of the discriminant function to classify accurately. The classification results are shown in Table 4. The overall classificatory ability is quite high (84.62%). However, it has to be compared with classificatory ability of a chance model to establish its superiority (Hair et al., 1983). Chance accuracy is determined by the formula $p^2 + (1-p)^2$, where "p" is the proportion of the sample in the first group. If the groups sizes were equal, as in our case, "p" would be 0.5 and the classification ability or accuracy of the chance model will be 50%. The accuracy of the chance model is much less than our discriminant model (84.62%). 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). The t-value was calculated as:

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

p = proportion correctly classified
k = chance accuracy
n = sample size

The t-value was found to be significant ($t = 6.48$, $p < 0.001$).

## Discussion Of The Results

Five variables — relative advantage, cost, product champion, top management support, and IS expertise — emerged as important variables in the discriminant analysis between adopters and non-adopters. An examination of the mean values for these variables in the two groups reveals that adopters had significantly higher values for relative advantage, product champion, and top management support and lower values for cost and IS expertise. It indicates that adopters perceived greater benefits from CASE technology compared to non-adopters, which is consistent with the findings of Sumner (1993). It also reinforces the findings in innovation adoption literature (Tornatzky and Klein, 1982) and IT adoption (Zmud, 1984) on the importance of relative advantage in adoption of new innovations. Since adoption of CASE is a major decision, most organizations will adopt it only if they see a clear need for it in the organization. Adopters have made the decision strongly believing that the technology will deliver its promised benefits, even though there have been some misgivings about whether all the benefits can really be realized. In fact, "uncertainty of benefits" has been found to be one of the major barriers that keep non-adopters from acquiring CASE technology (Sumner, 1993). Perhaps, non-adopters are taking a "wait and watch" attitude to see how the adopters fare in their implementation before they make their decision.

The need for CASE also varies among firms. CASE technology has typically been marketed as a product that helps to streamline mainframe operations by improving their system quality and productivity, two major weaknesses in the mainframe environment. In an IS environment that is primarily PC based with easy user interface and standard software purchased "off the shelf," CASE tools may not be that beneficial. We observed some of these patterns in our data on adopters and non-adopters that is shown in Table 5.

| Category | Non-Adopter | Adopter | t-value | Sig. |
|---|---|---|---|---|
| Info. Sys. Development | | | | |
| In-house DP | 63.4% | 72.5% | 1.61 | 0.111 |
| End-user | 4.6% | 5.3% | 0.34 | 0.733 |
| Outsourcing | 4.8% | 4.9% | 0.08 | 0.977 |
| Purchased | 27.2% | 17.6% | 1.85 | 0.068 |
| Hardware Platform | | | | |
| Mainframe based | 80.8% | 92.1% | 2.54 | 0.013 |
| PC based | 18.9% | 7.7% | 2.52 | 0.014 |
| Software Platform | | | | |
| Relational database | 34.0% | 31.7% | 0.26 | 0.798 |
| Traditional file based | 66.0% | 67.0% | 0.12 | 0.908 |

**Table 5. System Development Differences**

Non-adopters use more "off the shelf" software and less in-house development compared to adopters. They also have more PC-based development than mainframe development. Adopters have a longer backlog for new systems development and systems maintenance, which may have motivated them to adopt productivity enhancing tools such as CASE tools to relieve backlog pressure. These facts may better explain the reasons for lower value of relative advantage and being a non-adopter of CASE technology.

The fact that *cost* was found to be another significant variable reinforces our views. Non-adopters perceive CASE technology to be more costly compared to its benefits and therefore want to take a more cautious approach in the adoption decision. Lack of relative advantage over existing methods combined with perception of higher cost creates a significant barrier for adoption. Some of the earlier findings have supported this view since cost has been cited as a major barrier to introduction of CASE (Sumner, 1993; Everest and Alanis, 1993). An analysis of the sample indicates that a larger proportion of the bigger firms (sales greater than $500 mil.) and larger IS departments have adopted CASE. These firms, perhaps, have greater freedom in trying out new innovations without providing extensive justifications for its acquisition. Our sample has equal number of adopters and non-adopters in the medium size category and more non-adopters in the small size category.

Practitioners have also identified difficulties in justifying the investment in CASE as a major problem. Short-term payoffs are limited; and CASE typically provides long-term benefits, many of them intangible that cannot be converted to numerical dollar figures. CASE tools vary widely in scope ranging from simple stand-alone-PC-based systems that are capable of just drawing a few diagrams to integrated software that encompasses all the phases of the system development life cycle. The integrated software is more expensive, but delivers more benefits. The low-end tools do not provide much tangible benefit and can only be used as a tool for communication of information requirements and system specifications to the users.

Another important variable which differentiates adopters and non-adopters is product champion. Many earlier reports on CASE tools, including some case studies of firms, have highlighted the need for marketing the technology within the organization, particularly within the IS department, and creating a need and desire for acquiring the technology. Traditional mainframe environments running batch-mode, flat-file operations are conservative and are reluctant to try new technologies that can have a significant impact on their work practices. Furthermore, the fact that the tool can automate the coding operation can create additional resistance within the programming staff due to fear of job loss. A champion can be helpful to market the technology appropriately, explain the benefits, and outcomes in organization after the implementation. This may reduce the employees' inhibitions and set at rest unwarranted fears.

Time and again, it has been observed in empirical studies on IS that top management support is critical for successful initiation of new ideas in organizations. This reinforces Sumner's (1993) contention that top management commitment is one of two most important success factors for CASE implementation. CASE technology, with its significant impact on organizational work practices, possible internal resistance to adoption, and lack of immediate payoffs, clearly requires top management support for adoption. Without their support, many IS managers may be reluctant to take this high risk, high investment decision.

A surprising finding in the analysis is that IS expertise is greater for non-adopters than adopters, which is contrary to general expectations that firms with more IS expertise would have adopted CASE technology. A possible reason could be that firms with lower IS expertise see a greater need for CASE technology and therefore adopt it in the hope of improving productivity and quality. Our data analysis seems to confirm this. We divided the sample into two groups, firms with low and high IS expertise based on their mean values, and examined the values of various variables in the two groups. The most significant difference was in relative advantage. Firms with lower IS expertise perceived a greater relative advantage for CASE technology than firms with higher IS expertise. This finding has some support in prior research. Orlikowski (1993) argues that low expertise in traditional system development practices and knowledge is a facilitator to adoption of CASE tools. In a less technical environment, IS staff are more open to new ideas and therefore are willing to try CASE tools, since it promises less programming and more logical work, which is favored by less technical IS staff. On the other hand, in a group with high technical expertise, members may feel a loss of control over their systems and programs, possibly losing the ability to work with application development platforms because CASE tools typically work at the logical level and automate the code for the development platform.

the departmental level using "number of IS employees." Firms were classified on sales revenue into three groups — small (less than $100 mil.), medium ($101-500 mil.), large (greater than $500 mil.). They were classified on IS employees into four groups — small (1-10), medium (11-50), large (51-100), and very large (greater than 100). The results of the analysis are reported in Table 6.

The results indicate that there is a definite trend towards larger firms adopting CASE technology. A Chi-square test on sales revenue reveals that there is a significant difference (p < 0.0001) in sales revenue between adopters and non-adopters. There were more adopters in the large category and more non-adopters in the medium

| | Adopters | NonAdopter | Chi-Square(d.f) | Significance |
|---|---|---|---|---|
| Sales | | | 15.11 (2) | 0.001 |
| Small | 12 | 13 | | |
| Medium6 | 21 | | | |
| Large | 27 | 11 | | |
| IS Employees | | | 22.99 (3) | 0.001 |
| 1-10 | 6 | 15 | | |
| 11-50 | 11 | 23 | | |
| 51-100 | 9 | 5 | | |
| Greater than 100 | 19 | 2 | | |

**Table 6. Organizational Size Differences**

CASE tools, by removing the complexity of the development platforms, have made the task less challenging (Orlikowski, 1993) and thereby less attractive to firms with high IS expertise. Also, such firms may not perceive a need for CASE tools to improve their productivity and quality.

Although organizational size was not considered as a variable because of inconsistent evidence of its link to adoption or IS use (Rogers, 1983; Pierce and Delbecq, 1977; Ettlie, 1983; Raymond, 1985), we decided to investigate on an exploratory basis the link between size and CASE adoption. Size was measured at the organizational level using "sales revenue" and at

category. Since the sales revenue measure was handicapped by low response rate we used number of IS employees, as a measure of size. CASE adoption, as an organizational level IT adoption, may have a direct link with IS departmental size rather than overall organizational size. The results of a Chi-square test, shown in Table 6, reveal that there is a significant difference in IS department size between adopters and non-adopters. A closer look at the values in the various categories reveals that there are more adopters in the last two "large" category and more non-adopters in the first two, "small" and "medium," categories. CASE tools are more popular and useful in large scale systems development and if one could argue that larger IS departments would have larger systems development, these results clearly support that notion.

## Summary

This study, based on research on innovation adoption and IS implementation, examined the various organizational and technology characteristics that influence a firm to adopt or not adopt CASE technology. The study developed a research model based on prior exploratory and case-study-based research on CASE technology adoption and diffusion. The model identified seven factors as important predictors for adoption of CASE technology. A survey instrument was developed to measure the variables and a large-scale survey was administered to collect data from respondents in organizations. Ninety responses were received. The results of data analyses revealed that, of the seven variables, existence of a product champion, strong top management support, low IS expertise, perception that CASE technology has greater relative advantage over other alternatives, and a conviction on the cost effectiveness of the technology were found to be important factors to differentiate adopters from non-adopters. The results are consistent with findings in innovation adoption literature as well as case studies of many organizations' experience on CASE implementation. The only counter-intuitive finding was that IS expertise was greater for non-adopters than adopters. An explanation based on available data was provided but more data needs to be collected to better understand the reasons. The study's findings provides many interesting findings for practitioners and researchers that are discussed below.

## Limitations

There are some limitations that need to be recognized while interpreting the findings. The study used cross-sectional data that has obvious limitations in explaining causality. Another limitation of the study is the use of a single respondent in an organization, thereby creating some possibility for informant and common-method bias. The study also required adopters to respond based on conditions at the time of adoption which could be susceptible to memory recollection problems. However, since no detailed information was requested and the study was in the early stages of adoption of this technology, we do not expect this to be a serious limitation. A single-item measure was used for measuring two variables. Although the convenience sampling approach may introduce bias, we do not expect that to be a major problem since we notice that our sample is fairly uniformly distributed in terms of sales revenue and industry, and has an equal number of adopters and non-adopters.

## Implications for Practitioners

Costs compared to benefits seemed to be the most important inhibitor to adopting CASE technology. With greater emphasis on client/server computing and less expensive PC's, one should be able to see less expensive CASE software in the market. The CASE market is dominated by a few (three or four) large vendors and the competition is low. With more users adopting CASE tools, a larger market should motivate more vendors to enter the market, creating more competition and lower prices. There is also a trend for some of the database vendors to sell CASE technology along with their database software (e.g., Oracle). It is also necessary for IS managers to develop better schemes of justification using intangible benefits such as quality, productivity, etc. to project CASE as a more cost-beneficial tool.

Another concern related to CASE technology is the rapid change from mainframes to client/server systems. The role of case tools, primarily created for mainframes, in a client/server environment is not clear, even though some CASE software firms have reconfigured their software to support this environment. CASE technology will be more useful in a distributed environment where a central repository of database definitions and structure could be shared by various databases. However, the availability of easy front-end tools on the client side has reduced the need for code generation for user interface applications as there is more flexibility for the users to create their own screens and reports. These forces will change the nature and focus of CASE technology and create more or less relative advantage over other alternatives depending on an organization's approach to systems development.

One of the primary prerequisites for successful CASE adoption is a product champion to market the idea within the organization and a strong top management support in terms of commitment to the technology and resources to support its implementation. Developing a system using CASE technology requires significant investments in financial resources as well as substantial time and effort of system personnel and users. The payoffs from these investments are not immediately obvious as there are more intangible benefits than tangible benefits. However in the long run, it should be useful to most organizations to use CASE technology. In the short term, IS managers need a committed management and a highly resourceful product champion to overcome all the obstacles and maintain a positive and favorable attitude for the technology within the organization.

## Implications for Researchers

This study did not evaluate the diffusion and use of CASE technology. Case studies indicate that there are some success stories as well as some horror stories. Many consultants argue that success or failure is more dependent on the implementation process than on the technology *per se*. It would be useful to conduct a longitudinal study or even a cross-sectional study to determine the rate of success in the use of CASE technology and strategies for successful implementation.

Another interesting research issue would be to examine the impact of these factors on the next phase of the adoption-diffusion process, the use of CASE tools. It would be useful to determine if it is the same set of factors or a different set that are relevant as determinants in the diffusion stage. Perhaps the model needs to be expanded to bring in individual and task factors to better explain the use of CASE tools. This would be interesting since top management commitment, an important variable for adoption in this and other studies, was found to be unimportant for explaining the acceptance of CASE tools (Wynekoop et al., 1992). The study could throw more light on these counter-intuitive findings. Another research idea would be to examine the impact of IS expertise on the use of CASE tools. We could compare the counter-intuitive findings from this study on adoption with the findings from future studies on "use" to help us better understand the reasons for our findings.

Future studies could examine the impact of task and individual characteristics on the use of CASE tools. While adoption of CASE technology could have been a top-down organizational level decision influenced largely by the perception of a few key executives, individual use of CASE technology could be dependent on whether there is a good fit between the technology and the task characteristics. Researchers could examine whether traditional task related factors such as task responsibility, autonomy, uncertainty, etc., are relevant or newer task characteristics, more specific to CASE technology, need to be considered.

Another interesting aspect of integrated CASE is that it has a central repository, integrating the work of members in a project team. This could force many members on a project team to use CASE technology due to peer pressure or lack of other alternatives; i.e., inter-dependence of development staff may facilitate CASE diffusion. It may also inhibit diffusion if a few key members refuse to use the repository. Hence, we may need a certain "critical" mass in the development group to diffuse CASE technology rapidly if CASE can be considered to foster inter-dependencies. Studies on E-mail and other group support technologies may provide some insights on this topic.

Integrated CASE tools provide a range of features meeting the needs of various phases of the system development life cycle, ranging from IS planning to system maintenance, and other support activities such as project management. Preliminary indications are that only some of the features are used. For example, in our earlier research, we found that very few companies were using the IS planning features of the CASE tool. It would be interesting to determine which features are used and why others are not used. The role of CASE tools in business process reengineering needs to be examined, since significant amounts of information required for process redesign exist in the CASE repository.

## References


Alavi, M. (1993). "Making CASE an Organizational Reality — Strategies and New Capabilities." *Information Systems Management*, Spring, pp. 15-20.

Beath, C.M. (1991). "Supporting the Information Technology Champion." *MIS Quarterly*, Vol. 15, No. 3, pp. 355-374.

Burgleman, R. A. (1983). "Corporate Entrepreneurship and Strategic Management: Insights from a Process Study." *Management Science*, Vol. 28, December, pp. 1349-1364.

Burgleman, R.A. and Sayles, L.R. (1986). *Inside Corporate Innovation: Strategy, Structure, and Managerial Skills*, New York: Free Press.

Cash, J.I., McFarlan, W.F., McKenney, J.L., and Applegate, L.M. (1992). *Corporate Information Systems Management: Text and Cases*, (3rd ed), Homewood, IL: Irwin.

Chen, M., Nunamaker, J.F., and Weber, E.S. (1989). "Computer-Aided Software Engineering: Present Status and Future Directions." *DATA BASE*, Vol. 20, No. 3, pp. 7-13.

Chikofsky, E.J. (1988). *Reliability Engineering for Information Systems: The Emerging CASE Technology*. Cambridge, MA: Index Technology Corporation.

Churchill, G.A. Jr. (1979). "A Paradigm for Developing Better Measures of Marketing Constructs." *Journal of Marketing Research*, Vol. 16, No. 2, pp. 64-73.

Cooper, R.B. and Zmud, R.W. (1990). "Information Technology Implementation Research: A Technological Diffusion Approach." *Management Science*, Vol. 36, No. 2, pp. 123-139.

Crosslin, R.L., Bergin, T.J., and Stott, J.W. (1993). "Critical Factors Influencing the Future of Computer Aided Software Engineering." In Thomas J. Bergin (Ed.), *Computer-Aided Software Engineering*. pp. 616-636. Harrisburg, PA: Idea Group Publishing.

Ettlie, J. E. (1983). "Organizational Policy and Innovation Among Suppliers to the Food Processing Sector." *Academy of Management Journal*, Vol. 26, No. 1, pp. 27-44.

Ettlie, J. E. (1986). "Implementing Manufacturing Technologies: Lessons from Experience." In D. D. Davis and Associates (Eds.), *Managing Technological Innovation*, San Francisco: Jossey-Bass. pp. 72-104.

Ettlie, J. E., Bridges, W. P., and O'Keefe, R. D. (1984). "Organization Strategy and Structural Differences for Radical vs. Incremental Innovations." *Management Science*, Vol. 30, No. 6, pp. 682-695.

Everest, G.C., and Alanis, M. (1993). "Survey of CASE User Experiences." In Thomas J. Bergin (Ed.), *Computer-Aided Software Engineering*. Harrisburg, PA: Idea Group Publishing, pp. 227-246.

Fichman, R.G. (1992). Information Technology Diffusion: A Review of Empirical Research. In Janice I. Gross, Jack D. Becker, and Joyce J. Elam (Eds.), *Proceedings of the Thirteenth International Conference on Information Systems*. Dallas, TX: International Conference on Information Systems. pp. 195-206.

Grover, V. (1993). "An Empirically Derived Model for the Adoption of Customer-based Interorganizational Systems." *Decision Sciences*, Vol. 24, No. 3, pp. 603-640.

Guimaraes, T., Igbaria, M., and Lu, M. (1992). "The Determinants of DSS Success: An Integrated Model." *Decision Sciences*, Vol. 23, No. 2, pp. 409-430.

Hair, J.F. Jr., Anderson, R.E., Tatham, R.L., Grablowsky, B.J. (1979). *Multivariate Data Analysis*, Tulsa, OK:PPC Books.

Kimberly, J.R. (1981). "Managerial Innovation." In P.C. Nystorm and W.H. Starbuck (eds.) *Handbook of Organizational Design*, London: Oxford University Presss, pp. 84-104.

Kull, D. (1987). "The Rough Road to Productivity." *Computer Decisions*, Feb. 23, pp. 30-41.

Kwon, T.H. and Zmud, R.W. (1987). "Unifying the Fragmented Models of Information Systems Implementation." In R.J. Boland, Jr. and R.A. Hirschheim (Eds.), *Critical Issues In Information Systems Research*. Chichester, UK: John Wiley & Sons, pp. 227-251.

Lambert, Z.V., and Durand, R.M. (1975). "Some Precautions in Using Canonical Analysis." *Journal of Marketing Research*. Vol. 12, pp. 468-475.

Leavit, H.J. (1965). "Applying Organizational Change in Industry: A Structural, Technological, and Humanistic Approach." In J.G. March (ed). *Handbook of Organizations*, Chicago, IL.: Rand McNally.

Lehman, J.A. (1985). "Organizational Size and Information System Sophistication." *Journal of Management Information Systems*, Winter, Vol. 2, No. 3, pp. 76-86.

Lucas, H.C. Jr. (1978). "Empirical Evidence for a Descriptive Model of Implementation." *MIS Quarterly*, Vol. 2, No. 2, pp. 27-41.

Madique, M. A., and Zirger, B. J. (1984). "A Study of Success and Failure in Product Innovation: The Case of the U.S. Electronics Industry." *IEEE Transactions on Engineering Management*, November, pp. 192-203.

Martin, C.F. (1988). "Second Generation CASE Tools: A Challenge to Vendors." *IEEE Software*, March, pp. 46-49.

McLure, C. (1989). "The CASE Experience." *Byte*, Vol. 4, No. 14, pp. 235-244.

Munro, H. and Noori, H. (1988). "Measuring Committment to New Manufacturing Technology: Integrating Technological Push and Marketing Pull Concepts." *IEEE Transactions on Engineering anagement*, Vol. 35, No. 2, pp. 63-70.

Necco, C. R., Tsai, N. W., and Holgeson, K. W. (1989). "Current Usage of CASE Software." *Journal of Systems Management*, Vol. 40, No. 5, pp. 6-11.

Norman, R.J., and Nunamaker, J.F. (1989). "Integrated Development Environments: Technological and Behavioral Productivity Perceptions." *Proceedings of the 22nd Hawaii International Conference on Systems Sciences*, January.

Nunally, J.C. (1978). *Psychometric Theory*, New York: McGraw Hill, 1978.

O'Callaghan, R., Kaufmann, P.J., and Konsynski, BR (1992). "Adoption Correlates and Share Effects of Electronic Data Interchange Systems in Marketing Channels." *Journal of Marketing*, Vol. 56(April), pp. 45-56.

Orlikowski, W.J. (1989). "Division Among the Ranks: The Social Implications of CASE Tools for System Developers." In Janice I. Gross, John C. Henderson, Benn R. Konsynski (Eds.), *Proceedings of the Tenth International Conference on Information Systems*, pp. 199-210.

Orlikowski, W.J. (1993). "CASE As Organizational Change: Investigating Incremental and Radical Changes in Systems Development," *MIS Quarterly*, Vol. 17, No. 3, pp. 309-340.

Pierce, J.L., and Delbecq, A.L. (1977). "Organizational Structure, Individual Atrributes and Innovation." *Academy of Management Review*, Vol. 2, pp. 27-37.

Premkumar, G., Ramamurthy, K., and Nilakanta, S. (1994). "Implementation of Electronic Data Interchange." *Journal of Management Information Systems*, Vol. 11, No. 2, pp. 157-186.

Quinn, J.B. (1985). "Managing Innovation: Controlled Chaos." *Harvard Business Review*, Vol. 63, No. 3, pp. 73-84.

Rai, A., and Howard, G.S. (1993). "An Organizational Context for CASE Innovation." *Information Resources Management Journal*, Vol. 6, No. 3, pp. 21-34.

Raymond, L. (1990). "Organizational Context and Information Systems Success: A Contingency Approach." *Journal of Management Information Systems*, Spring, Vol. 6, No. 4, pp. 5-20.

Raymond, L. (1985). "Organizational Characteristics and MIS Success in the Context of Small Business." *MIS Quarterly*, Vol. 9, No. 1, pp. 37-52.

Robertson, T.S. and Gatignon, H. (1986). "Competitive Effects on Technology Diffusion." *Journal of Marketing*, July, Vol. 50, pp. 1-12.

Rogers, E.M. (1983). *Diffusion of Innovations*, (3rd ed.), New York: The Free Press.

Runge, D.A. (1985). *Using Telecommunications for Competitive Advantage*, Unpublished doctoral dissertation, England: Oxford University.

Russo, N.L., and Kumar K. (1992). "Studying the Impact of Information Technology Innovations in Organizations: The Influence of Individual Characteristics, Innovation Characteristics, and the Innovation Introduction Process," *Working Paper.*

Sanders, G.L., and Courtney, J.F., (1985). "A Field Study of Organizational Factors Influencing DSS Success." *MIS Quarterly*, Vol. 9, No. 1, pp. 77-93.

Schultz, R.L., and Slevin, D.P., (eds.) (1975). *Implementing Operations Research/Management Science.* New York: American Elsevier.

Statland, N. (1989). "Payoffs Down the Pike: A CASE Study." *Datamation*, Vol. 35, No. 7, p. 32.

Sumner, M. (1993). "Factors Influencing the Adoption of CASE." In Thomas J. Bergin (Ed.), *Computer-Aided Software Engineering*. Harrisburg, PA: Idea Group Publishing, pp. 130-155

Tornatzky, L.G. and Klein, K.J. (1982). "Innovation Characteristics and Innovation Adoption-Implementation: A Meta-Analysis of Findings." *IEEE Transactions on Engineering Management*, EM-29, No. 1, pp. 28-45.

Van de Ven, A.H. (1986). "Central Problems in the Management of Innovation." *Management Science*, Vol. 32, No. 5, pp. 590-607.

Velde, R.V., (1992). "CASE Adoption at Imperial Oil." *Journal of Systems Management*, Vol. 43, No. 9, pp. 24-38.

Wynekoop, J.L. (1992). "Strategies for Implementation Research: Combining Research Methods." In Janice I. Gross, Jack D. Becker, and Joyce J. Elam (Eds.), *Proceedings of the Thirteenth International Conference on Information Systems* Dallas, TX: International Conference on Information Systems, pp. 185-193.

Wynekoop, J., Senn, J.A., Conger, S.A. (1992). "The Implementation of CASE tools: An Innovation Diffusion Approach." in Kendall K.E. (ed), *The Impact of Computer Supported Technologies on Information Systems Development*, B.V., North Holland: Elsevier Science Publishers,

Yourdon, E. (1989). "Serious CASE In The 90's: What Do We Do When the Novelty Wears Off?" Show CASE Conference IV, October 10.

Zaltman, G., Duncan, R., Holbeck, J. (1973). *Innovations and Organizations*, New York: John Wiley & Sons.

Zeller, R.A., and Carmines, E.G., (1980). *Measurement in Social Sciences: The Link Between Theory and Data*, New York: Cambridge University Press.

Zmud, R. W. (1984). "An Examination of 'Push-Pull' Theory Applied to Process Innovation in Knowledge Work." *Management Science*, Vol. 30, No. 6, pp. 727-738.

## About the Authors

**G. PREMKUMAR** is an Assistant Professor of Information Systems in the College of Business at Iowa State University. He received his Ph.D. in MIS from the University of Pittsburgh, a graduate business degree from Indian Institute of Management and an undergraduate degree in engineering from India. He has over nine years of industrial experience in the areas of production planning and information systems. His research papers have been published in *Decision Sciences, Information Systems Research, Journal of Management Information Systems, Information & Management, Omega, International Journal of Man Machine Studies*, and other leading journals and conference proceedings. His current research interests include strategic IS planning, technology adoption and diffusion, inter-organizational systems, and telecommunications management.

**MICHAEL POTTER** is an IS manager in a large home building company in Tucson, Arizona. He received his graduate degree in business from Iowa State University and an undergraduate degree in Business from Oregon State University. Prior to his graduate studies he was an IS manager in a credit union in Oregon. His research interests include on-line services and technology adoption and diffusion.

## Appendix

## Operationalization of Research Constructs

**Relative Advantage**

1. CASE tools would produce better quality systems than our current methods.
2. CASE tools would reduce system development efforts compared to current methods
3. CASE tools would reduce system maintenance efforts compared to current methods
4. CASE tools would enforce application development standards better than our current methods
5. CASE tools would create better documentation than our current methods.

**Compatibility**

1. CASE tools would be compatible with our existing software platform
2. CASE tools would be compatible with our existing hardware platform
3. CASE tools would be compatible with our existing applications development methodology
4. CASE tools would be compatible with our existing information systems culture
5. IS employees would fear the loss of jobs due to introduction of CASE tools
6. IS employees would fear that they lack the capability to use CASE tools
7. IS employees would fear CASE tools may cause undesirable changes in departmental power structures

**Complexity**

1. CASE tools would be very complex for our analysts/ programmers to use

**Cost**

1. The initial purchase price of a CASE tool system would be greater than its benefits
2. The cost of training for CASE tools would be greater than its benefits

**Top Management**

1. Top management would support introducing CASE tools
2. Top management has a desire to portray our firm as a leader in the use of new technology
3. Top management would be willing to take the risk (both financial and organizational) involved in adopting CASE tools

**Product Champion**

1. A product champion exists façilitating the adoption of CASE tools

**IS expertise**

1. Our IS department has experience with structured design and programming methods
2. Our IS department has experience with process modelling methods (eg: data flow diagram etc.)
3. Our IS department has experience with data modelling methods (eg: E-R models etc.)