THE EFFECT OF INCENTIVES AND CONTROL ON INTRAORGANIZATIONAL INFORMATION TECHNOLOGY USAGE: A PRINCIPAL-AGENT MODEL

A Dissertation

Presented to

The Faculty of the College of Business Administration

The University of Houston

In Partial Fulfillment

of the Requirement for the Degree of

Doctor of Philosophy

by

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Dedicated to my father, my mom, and my wife

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ABSTRACT

An understanding of when and how individual users within an organization decide on using new information technologies (IT) are important concerns of MIS researchers and practitioners. Current models of IT usage do not address why and how managers can influence the IT utilization behavior of organizational users, and are therefore of limited use in intraorganizational contexts. The purpose of this research was to develop and test a theoretical model of intraorganizational IT usage that can help account for this deficiency, and thereby advance our knowledge of IT implementation/diffusion.

A intraorganizational IT usage model was developed by drawing on principal-agent research in the microeconomics literature. By viewing managers as principals and users as agents, the principal-agent model (PAM) demonstrated how managers can employ incentives and control structures to motivate IT usage within organizations. Key PAM constructs (i.e., incentive level, incentive type, goal incongruence or behavioral intention, risk aversion, monitoring, behavioral evaluation type, and repeated contracts) were linked to intraorganizational IT usage (operationalized as IT acceptance and infusion) within the theory of planned behavior (TPB) framework.

Data for the research was collected using student subjects, who were awarded bonus points toward their class grade for participating in a business task (promotional budget

allocation decision) that involved the potential use of a new IT (Microsoft Excel's SOLVER tool). Incentive and control variables in PAM were operationalized dichotomously (e.g., low versus high), and manipulated via treatment group assignment. These and other model variables were measured perceptually using multiple-item Likert scales for purposes of data analysis. In addition, usage data was recorded objectively using a network auditing software package.

Two pilot studies were conducted to examine the overall feasibility of the research project and to develop a psychometrically validated research instrument. Model testing was done using data collected from a subsequent experimental study via a latent variable modeling approach called partial least squares (PLS). Results of the analysis provided overall support to PAM associations, confirming the main effects of outcome-based and behavior-based incentives and interaction effects of behavior-based incentives with control structures such as monitoring, behavioral evaluation type, and repeated contracts on behavioral intention.

Comparison of TPB with and without PAM variables helped isolate the explanatory power of PAM variables. Results indicated that though attitude was the most significant predictor of behavioral intention and IT usage (explaining about 30 percent of the variance on intention), addition of subjective norm, defined as an aggregation of incentive and control variables, can explain an additional nine percent of the variance. This is an important finding in IT implementation/diffusion research since prior studies, which paid little attention to the determinants of subjective norm, were unable to explain the effect of this variable on IT usage.

Results from this research are expected to provide MIS practitioners with normative guidelines on designing incentives and control structures that can effectively motivate IT usage within their organizations. This study can also benefit IT implementation/diffusion research by providing a theoretical model to predict the effect of managerial influences (incentives and control) on intraorganizational IT usage, thereby extending current IT usage models to the organizational context. Moreover, by introducing the ideas of self-interest, information asymmetry, risk aversion in organizational thinking, it provides a link between the traditionally segregated economic and political schools of thought in MIS research.

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Chapter I

INTRODUCTION

Investments in information technology (IT) represent a sizable portion of an organization's capital budget expenditure today. Recent surveys indicate that worldwide investments in IT for the year 1994 exceeded $430 billion (Metcalfe 1995), while the total IT investment base is currently estimated at over $1 trillion (Kneale 1995). Organizations decide to invest in IT for various reasons: to improve the productivity of their knowledge workers (Curley and Pyburn 1982), to enhance the quality of work life (Blacker and Brown 1985), to improve decision making (Keen and Scott-Morton 1978), to enhance the overall competitiveness of the organization in the business environment (Ives and Learmonth 1984), and so forth. However, many of the intended benefits may not be realized if the IT is not utilized appropriately by individual users within these organizations (Moore and Benbasat 1991). An understanding of when and how organizational users decide on utilizing a new IT is therefore of significant concern to management information systems (MIS) researchers and practitioners. In particular, managers are interested in knowing what can be done to proactively influence IT usage within their organizations. This study addresses this important topic by developing and testing a normative model of intraorganizational IT usage that focuses on the role of managerial incentives and control mechanisms in motivating IT usage within organizations.

This chapter provides a broad overview of the topic and mode of inquiry, and is organized in four sections. It begins by discussing the purpose and relevance of the research problem. This is followed by a summary of the proposed model of IT usage and its theoretical underpinnings. The third section provides an overview of the research methodology employed in this study. The chapter ends with an outline of the remaining chapters in this dissertation.

1.1 Research Problem

Information technology (IT) can be defined as "an artifact whose underlying technological base is comprised of computer or communications hardware and software" (Cooper and Zmud 1990). Organizations invest millions of dollars in IT, with the expectation that their knowledge workers will appropriately utilize the IT to further organizational goals. However, availability of IT does not guarantee its utilization by organizational members (Howard and Mendelow 1991). In fact, the term "shelfware syndrome" has been coined to describe software productivity packages that sit idle on bookshelves without being used by the persons for whom they are intended (Bowen 1986). A relevant question asked by many MIS practitioners is therefore, how can managers motivate organizational members to appropriately utilize IT provided for their use.

The problem of intraorganizational IT usage has been investigated in depth in IT implementation/diffusion research. Prior empirical research in this area indicate that IT usage is consistently related to individual variables, such as beliefs, attitudes, and intentions (Davis, Bagozzi, and Warshaw 1989, Mathieson 1991), and managerial variables, such as management support and sponsorship (Lucas 1978, Ginzberg 1981b, Leonard-Barton and Deschamps 1988). Unfortunately, the reasons behind these associations remain quite unclear. Current theories of IT usage, such as the technology acceptance model or TAM (Davis, Bagozzi, and Warshaw 1989) and the theory of planned behavior or TPB (Mathieson 1991, Taylor and Todd 1995), explain how individual perceptions and attitudes affect their IT usage behavior but do not address how such perceptions and attitudes can be manipulated by organizational managers. Furthermore, very little research has attempted to integrate micro-level individual variables with macro-level managerial variables to develop a comprehensive understanding of intraorganizational IT usage. Consequently, research in this area has provided little normative guidance for practitioners interested in effective implementation/diffusion of IT within their organizations.

This study addresses these concerns by examining how managers can influence organizational members' IT usage behavior by employing incentives and control structures. Principal-agent research in the microeconomics literature is employed to understand the relationship between organizational managers and users concerning IT usage. These ideas are then integrated within the TPB framework to develop a principal-agent model of intraorganizational IT usage for subsequent empirical testing. The research questions addressed are: (1) how do incentives affect organizational members' use of IT, (2) what are potential conflicts that mediate the effect of incentives on individual IT usage behavior, and (3) what control mechanisms can be employed to mitigate such conflicts.

This study has two broad goals. First, it has an epistemological goal in that it attempts to advance our current state of knowledge in IT implementation/diffusion by providing the missing linkage between managerial influences and intraorganizational IT usage. Second, it has a normative goal in that it is intended to aid managers in designing strategies (e.g., appropriate incentives and control structures) for better and more effective management of IT implementation within their organizations.

1.2 Overview of Research Model

Principal-agent research (Jensen and Meckling 1976, Rees 1987, Sappington 1991) from the microeconomics literature was employed in this study to develop a theoretical model of intraorganizational IT usage. The proposed model holds that managerial influences on organizational members' IT usage behavior can be modeled in form of a principal-agent relationship, with managers acting as principals and users as agents. From a rational perspective, managers acquire IT to achieve organizational benefits such as productivity gains or increased profits, and want users to utilize the IT to its fullest potential so that the expected benefits are realized (Leonard-Barton and Deschamps 1988). However, utilizing a new IT typically requires effort on the part of users in overcoming barriers to usage, such as learning curves (Attewell 1992) and/or social inertia (Keen 1981), and may therefore be resisted by organizational members. In order to induce potential users to expend the necessary effort, managers can provide them with incentives (e.g., commissions, promotions, and praise) for IT use and/or penalties (e.g., threats and dismissals) for non-use. Although managers can observe the outcomes of IT usage (e.g., reduction in customer response time), the actual user behavior (i.e., appropriateness of IT usage) cannot be observed or inferred. This leads to an information asymmetry and potential opportunistic behavior on the part of users. The proposed principal-agent model (PAM) explains how incentives can motivate individual IT usage, examines the impact of different incentive levels and incentive types (e.g., outcome-based versus behavior-based) on IT usage under different cases of information asymmetries, and prescribes different forms of control that can best mitigate opportunistic behavior arising from such asymmetries.

As explained later, the IT usage model developed in this study theorizes incentives and control as important determinants of the subjective norm construct in TPB, which to date, has received little attention in the implementation/diffusion literature. In doing so, the proposed model extends current theories of IT usage such as TAM and TPB from personal-use settings to organizational contexts. By virtue of its focus on managerial roles, this model is of greater relevance to organizational managers interested in enhancing the chances of successful IT implementation/diffusion.

1.3 Overview of Research Methodology

A laboratory experiment was used to empirically test the proposed principal-agent model of IT usage. The selection of the laboratory approach was motivated by several reasons. First, selection of research methodologies for any scientific inquiry involves a fundamental tradeoff between internal validity (causality) and external validity (generalizability) of the final results, and one can be achieved only at the cost of the other. In cases where both forms of validity cannot be achieved to reasonable extents, it has been suggested that researchers seek internal validity as the minimum criteria (Huck, Cormier, and Bounds 1974). Internal validity is also of critical importance in areas such as the current study, where theory building is in its formative stages and there is little empirical research to draw from. Second, isolation of an experimental setting from the real world makes it possible to control for extraneous factors that may confound the hypothesized associations, and therefore, a higher degree of causality can be expected from a laboratory-based approach. Third, organizational considerations typically prevent the manipulation of independent variables in field settings, and inadequate manipulation of treatment variables may make it difficult to detect the expected associations. Fourth, given the novelty associated with different incentive and control variables examined in this study, it is extremely difficult to find a sample of organizational users, that would provide a reasonable sample size for each treatment group. Given these considerations, a laboratory experiment was selected for empirically testing the proposed model.

Students from an introductory computer applications class at a large southwestern university served as subjects in this study. Subjects received bonus points toward their class grade as incentives for participating in a business task (a managerial budget allocation problem) that could potentially benefit from the use of IT. Microsoft Excel's SOLVER was the IT recommended for performing this task. Incentives and control were manipulated by varying the number of bonus points awarded to subjects and the conditions under which these points were awarded.

The experimental design employed in this study was a multi-group posttest only design with six treatments (Huck, Cormier, and Bounds 1974). Each of the six treatment groups was an unique combination of five incentives and control variables: incentive level, incentive type, monitoring, behavioral evaluation, and repeated contracts. These variables were manipulated dichotomously (e.g., low versus high, present versus absent) via random assignment of subjects to treatment groups. Other model variables measured and tested in this study include goal incongruence (behavioral intention), risk aversion, subjective norm, attitude, usefulness, and ease of use.

Multiple methods of data collection were employed for measuring the research variables. Incentive and control variables were manipulated by randomly assigning subjects to six treatment groups. The effects of these treatments on subjects were verified using perceptual measures. The perceptual data was also used for model testing since IT usage depends not on objective treatments but on subjects' perceptions of these treatments (Moore and Benbasat 1991). Intraorganizational IT usage was operationalized as acceptance (use versus non-use of IT) and infusion (extent of IT usage), and measured objectively using an auditing software package called SofTrack and perceptually via a post-treatment questionnaire. Objective usage measures are often suggested as a remedy to possible biases in perceptual responses that plague much of IT implementation research (Trice and Treacy 1988). Multiple data collection techniques also facilitated "methodological triangulation" (Nilakanta and Subramanian 1994), thereby improving the strength of the causal inferences.

A latent variable modeling approach called Partial Least Squares (PLS) (Wold 1981) was used to test causal associations in the proposed model, and to compare its explanatory power to that of TPB. Results of the analysis provided support for the hypothesized associations between incentive and control variables and IT usage, thereby indicating that these variables are indeed important constituents of managerial influence in organizational settings. The results also demonstrated that PAM can explain an additional nine percent of the variance in intraorganizational IT usage, over and above the attitudinal variables suggested by TAM.

1.4 Summary of Remaining Chapters

The remainder of this dissertation is organized into five chapters. Chapter II reviews prior research in the IT implementation/diffusion literature related to the problem of intraorganizational IT usage, examines limitations in our current understanding in this area, and points out the need for a comprehensive model of IT usage. Chapter III examines the theoretical ideas underlying principal-agent research in the microeconomics literature and applies it to the specific context of intraorganizational IT usage. By incorporating PAM constructs within a broader TPB framework, a theoretical model of intraorganizational IT usage is developed, which highlights managerial incentives and control as important determinants of IT usage within organizations. Chapter IV justifies the experimental approach employed for testing the above propositions, as well as discusses methodological issues such as research setting, experimental design, and operationalization of variables. Chapter V describes the results of instrument validation and data analysis procedures, utilizing data from two pilot and one experimental studies. The concluding chapter compares the findings of the study with that of prior research in this area, discusses the implications of these findings for MIS researchers and practitioners, points out limitations of this research, and suggests avenues for future research.

Chapter II

LITERATURE REVIEW

The research proposed in this dissertation builds on an enormous body of prior work related to information technology (IT) usage within organizations[1]. This chapter reviews literature from two streams of MIS research, namely IT implementation and IT diffusion, that have examined the problem of IT usage in considerable detail. The purpose of this review is three-fold: (1) to provide a bridge between the two research streams that have historically examined a common problem from different perspectives, (2) to outline limitations in our current state of knowledge in each of these areas, and (3) to establish the need for a more comprehensive model of intraorganizational IT usage, which is introduced in Chapter III.

This chapter is organized in four sections. The first section examines the parallels between IT implementation and diffusion research and highlights potential benefits that can be obtained by synthesizing these literatures. These similarities are used to present the

[1] A computerized search of ABI/Inform business database found 3037 publications in this area in the three and half year period between January 1992 and July 1995. Each article included in this count had the words "information technology" or "information system" and "use" in their title, abstract, or key word list.

rationale for choosing IT usage as the dependent variable in the current study and to outline the scope of this study within the broader context of IT usage research. The second section reviews individual and managerial determinants of intraorganizational IT usage as identified from IT implementation/diffusion research. The third section examines theories that attempt to link these determinants to the dependent variable. The chapter ends by discussing the limitations of prior research and indicating how the current study can help address some of these shortcomings.

2.1 IT Implementation/Diffusion Research

Intraorganizational IT usage can be viewed simultaneously as an instance of IT implementation and as the deployment of an organizational innovation (Howard and Mendelow 1991) and can therefore be studied from two perspectives of MIS research: IT implementation and IT diffusion. The functional parallels between these two research streams is highlighted by Kwon and Zmud's (1987, p. 231) definition of IT *implementation* as "an organizational effort to *diffuse* an appropriate information technology within a user community" [emphasis added].

The roots of IT implementation research can be traced back to a classic article by Churchman and Schainblatt (1965), where the authors first raised the need for mutual understanding between managers and researchers for successful implementation of IT. Early implementation research evolved in conjunction with the management science and operations research (MS/OR) literatures because managers were often faced with difficulties in implementing computer-based MS/OR models in their organizations, despite their technical soundness (Schultz and Ginzberg 1984). Since then, IT implementation has burgeoned into one of the largest and growing bodies of research in MIS.

The general body of innovation diffusion research dates back to the adoption of hybrid corn by Iowa farmers in the 1940's (Ryan and Gross 1943); however, interest in IT diffusion is of a relatively recent origin. An *innovation*, in this context, is defined as "an idea, practice, or object that is perceived as new by an individual or some other unit of adoption" (Rogers 1983, p. 11) and *innovation diffusion* refers to the spread or dissemination of knowledge of an innovation and its consequent adoption among members of a social system. Innovation diffusion researchers have distinguished between two types of innovations: technical innovations that affect the way in which goods or services are produced, and administrative innovations that impact organizational structure, forms, and processes (Zaltman, Duncan, and Holbek 1973, Kimberly and Evansinko 1982). IT new to an organization can be viewed as either a technical or an administrative innovation (Howard and Mendelow 1991), and therefore, the models and findings from the general body of innovation diffusion research can be applied to the specific case of IT diffusion research.

Similarities between the IT implementation and IT diffusion research streams can be observed on at least three counts. First, much of the implementation and diffusion literatures share a common dependent variable, namely IT usage. Second, independent variables (e.g., individual and organizational factors) believed to affect IT usage are, to a significant extent, similar across the two streams. Third, commonalties can be observed in the models linking the independent with the dependent variables across the two streams. These similarities are discussed at length in subsequent sections of this chapter.

Despite these similarities, research on IT implementation and diffusion have historically been conducted from different perspectives. While implementation research has focused more on organizational and user characteristics, diffusion research, until recently, has been centered on the IT itself (Howard and Mendelow 1991). Critics contend that the current mixed, inconsistent, and fragmented state of knowledge in IT implementation/diffusion research can be attributed in part to our inability to integrate findings across these two streams and develop a holistic view of IT implementation/diffusion (Kwon and Zmud 1987). It has been suggested that viewing implementation from an innovation diffusion perspective can provide new, synergistic insights into the complex dynamics underlying the implementation process (Cooper and Zmud 1990).

The remainder of this section explores the similarities between the IT implementation and diffusion streams in an effort to first justify the selection of IT usage as the dependent variable in the current study, and then to define the scope of this study within a broader framework of IT usage. The final part outlines some of the limitations of the classical innovation diffusion model (Rogers 1983) in the context of intraorganizational IT usage and describes how the current study hopes to address these limitations.

2.1.1 The Dependent Variable

The dependent variable in IT implementation research is implementation success (alternatively called IS effectiveness or MIS success), while that in IT diffusion research is IT usage. This is so because IT implementation is concerned with putting an IT to effective use in an organization, while IT diffusion attempts to describe how use of the IT (as an innovation) spreads among members of a social system (e.g., an organization), irrespective of effectiveness. This section explores the linkage between the dependent variables in these two areas and points out the rationale for choosing IT usage as the dependent variable of interest in the current study.

Implementation success, the dependent variable in IT implementation research, has been an elusive one to define and a topic of considerable debate among MIS researchers for the last thirty years (DeLone and McLean 1992). Suggested surrogates of implementation success include system quality, information quality, IT usage, user satisfaction, individual impact of IT, and organizational impact of IT (DeLone and McLean 1992). Different researchers have addressed different aspects of implementation success, making integration across studies difficult. The problem is compounded by the fact that these surrogates may not be necessarily correlated (Srinivasan 1985). For example, a data processing employee may use an IT regularly because it is his job to do so, but have low user satisfaction because such usage does not lead to any personal benefits. Conversely, a corporate executive may use an decision support system sparingly, but gain a lot from such use, resulting in high levels of satisfaction. Also, as indicated by the political conflict stream of

MIS research (Markus 1983, Kling and Iacono 1984), users may be satisfied with an IT for reasons that have little to do with its usage.

Of the proposed surrogates of implementation success, the more widely used ones are IT usage, user satisfaction, and user performance (Ives and Olson 1984, Kwon and Zmud 1987, Alavi and Joachimsthaler 1992). Though there is little empirical evidence of a clear precedence among these surrogates, it is evident that an IT must be used to some degree in order to achieve either satisfaction or performance (Srinivasan 1985, Baroudi, Olson, and Ives 1986). In other words, usage is a necessary, though not sufficient, condition for either satisfaction or performance. Therefore, implementation research views IT usage as a prerequisite to organizational effectiveness.

Innovation diffusion research, on the other hand, has been concerned with explaining adoption behavior, where adoption is defined as the "decision to make full *use* of an innovation" (Rogers 1983, p. 21) [emphasis added]. An innovation may be adopted at organizational or individual levels (Leonard-Barton 1987); organizational or "primary" adoption refers to the organizational decision to invest in an IT, while individual or "secondary" adoption (sometimes called "acceptance" in the implementation literature) refers to individual-level decisions regarding IT usage. IT usage is therefore the primary dependent variable from the IT diffusion perspective.

Given that IT diffusion research focuses on usage as the dependent variable and that implementation research views IT usage as a necessary condition for implementation success, IT usage is selected as the dependent variable of interest in the current study. Note in this context that IT usage refers to organizational members' behavior, while implementation success focuses on the outcomes of such behavior. As explained in Chapter III, the model proposed in this dissertation provides a linkage between user behavior and behavioral outcomes, and thereby, provides a bridge between the implementation and diffusion camps of MIS research.

2.1.2 Categories of Implementation/Diffusion Research

Most research in IT implementation/diffusion can be grouped into two broad categories (Prescott and Conger 1995): (1) *factors research* that attempts to identify factors (e.g., individual and organizational) potentially related to the dependent variable (e.g., Fuerst and Cheney 1983, Ives and Olson 1984), and (2) *stage research* that is concerned with identifying the sequence of stages unfolding over time during organizational implementation/diffusion of IT (e.g., Cooper and Zmud 1990). Note that this categorization is in contrast to the traditional distinction between factors research and process research, since there has been virtually no process research in this area.

Much of the empirical research in IT implementation/diffusion belongs to the factors research category, attempting to identify factors (independent variables) that can potentially impact IT usage (dependent variable). Factors thus identified can be grouped into five broad classes: individual, organizational, technological, task-related, and environmental (Kwon and Zmud 1987). A representative sample of such factors and their empirical associations with IT usage are listed in Table 2.1. Factors of relevance to the current study are discussed in Section 2.2.

Table 2.1 Factors affecting IT usage
(modified from Kwon and Zmud 1987)

Independent variables	*Association with IT use*	*Illustrative studies*
Individual factors		
Cognitive style (systematic/heuristic, high/low-analytic, etc.)	Mixed *	Bariff and Lusk (1977), Dickson et al. (1977), Benbasat and Taylor (1978), Zmud (1979), Huber (1983), Robey and Farrow (1986)
Attitude toward IT	Positive	Lucas (1975), Ginzberg (1981), Swanson (1982), Davis et al. (1989), Alavi and Joachimsthaler (1992)
Beliefs about IT	Positive	Grantham and Vaske (1985), Igbaria (1989), Davis (1989), Davis, Bagozzi, and Warshaw (1989)
Demographics (age, education, experience)	Weakly positive	Guthrie (1973), Lucas (1975), Lucas (1978), Zmud (1979), Leonard-Barton and Deschamps (1988)
Personality (locus of control, dogmatism)	Mixed *	Zmud (1979)
Situational factors (user involvement)	Mixed *	Ives and Olson (1984), Baroudi, Olson, and Ives (1986)
Organizational factors		
Centralization	Positive *	Robey and Zeller (1978), Lind, Zmud, and Fischer (1989)
Formalization	Positive	Robey and Zeller (1978)
Specialization	Positive	Robey and Zeller (1978)
Communication / interconnectedness	Mixed *	Brancheau and Wetherbe (1990), Nilakanta and Scamell (1990), Kwon (1990)
Size	Positive	Lind, Zmud, and Fischer (1989), Bretschneider and Wittmar (1993)
Management support	Positive	Lucas (1975), Maish (1979), Zmud and Cox (1979), DeLone (1988), Leonard-Barton and Deschamps(1988)
User training	Positive	Guthrie (1973), Sanders and Courtney (1985), Ginzberg (1981a)
Management commitment to change	Positive	Ginzberg (1981), Mankin, Bikson, and Gutek (1985), Ball et al. (1987)
Technological factors		
Usefulness	Positive	Goodwin (1987), Davis, Bagozzi, and Warshaw (1989), Mathieson (1991)
Ease of use	Positive	Goodwin (1987), Davis, Bagozzi, and Warshaw (1989), Mathieson (1991)
Compatibility	Positive	Cooper and Zmud (1990), Mathieson (1991)
Task-related factors		
Task uncertainty	Positive	Blandin and Brown (1977)
Environmental factors		
Business uncertainty	Positive	Benbasat and Schroeder (1977), Pierce and Delbecq (1977)

Note: Empirical findings contrary to expectations are indicated by asterisk (*)

Stage models, on the other hand, conceptualize IT implementation/diffusion as a sequence of stages, each of which must be attended in order to achieve implementation success. These models are fundamentally derived from the theory of change, originally proposed by Lewin (1947) and subsequently modified by Schein (1969), which holds that any change process should consist of three sequential stages: unfreezing, moving, and re-freezing. Introducing a new IT within an organization typically involves changes in organizational roles, structure, and processes, with IT managers acting as change agents (Sorensen and Zand 1975), and hence, the Lewin-Schein model is considered appropriate for IT implementation research.

Table 2.2 depicts some of the widely cited stage models in the IT implementation/diffusion literature. Though the models vary in terminology and in their beginning and ending points, a significant degree of overlap exists among individual stages of these models. In one of the more comprehensive stage models, Cooper and Zmud (1990) described IT implementation as a process consisting of six stages: initiation, adoption, adaptation, acceptance, routinization, and infusion. In the *initiation* stage, an organization first feels the need for a new IT, due to a need-pull or technology-push or a combination of both (Zmud 1984). The *adoption* stage represents the organization's acquisition of an IT and allocation of resources necessary to implement it. In the *adaptation* stage, the IT is tailored to the specific needs of organization and organizational procedures are modified to accommodate the IT. The *acceptance* stage represents organizational members' commitment to use the IT. In the *routinization* stage, the IT ceases to be a new entity and becomes a part of the everyday activities of the users. Finally, in the *infusion* stage, the IT is used to its fullest potential. According to this classification, implementation can be considered successful if the IT is appropriately infused within the target user population.

Table 2.2 Stage Models of IT Implementation/Diffusion (modified from Wolfe 1994)

Author	*Proposed Stages*
Sorensen and Zand (1975)	Unfreezing - Moving - Refreezing (Based on the Lewin-Schein model)
Ginzberg (1979)	Scouting - Entry - Diagnosis - Planning - Action - Evaluation - Termination (Based on the Kolb-Frohman model)
Zmud (1982)	Initiation - Adoption - Implementation
Kwon and Zmud (1987)	Initiation - Adoption - Adaptation - Acceptance - Use/performance/satisfaction - Incorporation
Cooper and Zmud (1990)	Initiation - Adoption - Adaptation - Acceptance - Routinization - Infusion

Most empirical research in IT implementation/diffusion can be placed in a two-dimensional framework based on the type of factors examined and stage being addressed, as shown in Table 2.3. In this table, areas addressed by prior research are indicated by asterisk, while areas addressed in the current study are labeled with the letter "C." This framework offers a convenient way of mapping areas where prior implementation/diffusion research has been concentrated and identifying areas where research has been lacking. In addition, it also defines the scope of the current study within the broader context of IT implementation/diffusion research.

The current study is concerned with understanding individual motivations regarding IT usage and how managers can influence such motivations. Therefore, as depicted in Table 2.3, individual and organizational factors are of relevance to this study. Of the six stages in the implementation/diffusion process, though the first three stages may indirectly impact individual users' motivation to utilize IT, the final three stages directly focus on this issue. Of these later stages, acceptance and infusion are of greatest interest to the current research because they respectively address organizational members' commitment toward IT use and their disposition toward a high degree of use. IT acceptance and infusion are described in greater detail in Chapter IV.

Table 2.3 Scope of the Current Study

Stages in IT implementation	*Factors affecting IT implementation* Individual	Organizational	Technological	Task-related	Environmental
Initiation			*	*	
Adoption		*	*		
Adaptation	*	*			
Acceptance	*, C	*, C	*	*	*
Routinization					
Infusion	*, C	C			

Note: Research areas covered by the current study are indicated by "C" while those covered by prior IT implementation/diffusion research (updated from Cooper and Zmud 1990) are indicated by "*"

2.1.3 Shortcomings of Innovation Diffusion Model

Given the similarities between implementation and diffusion streams of MIS research, it may seem likely that the widely-cited classical innovation diffusion model, developed by Rogers (1983), would be ideally suited to studying problems related to IT implementation. However, as discussed below, Rogers' model suffers from several limitations that restrict its generalizability to organizational contexts. The purpose of this discussion is to identify shortcomings in this model that can be improved upon in this study.

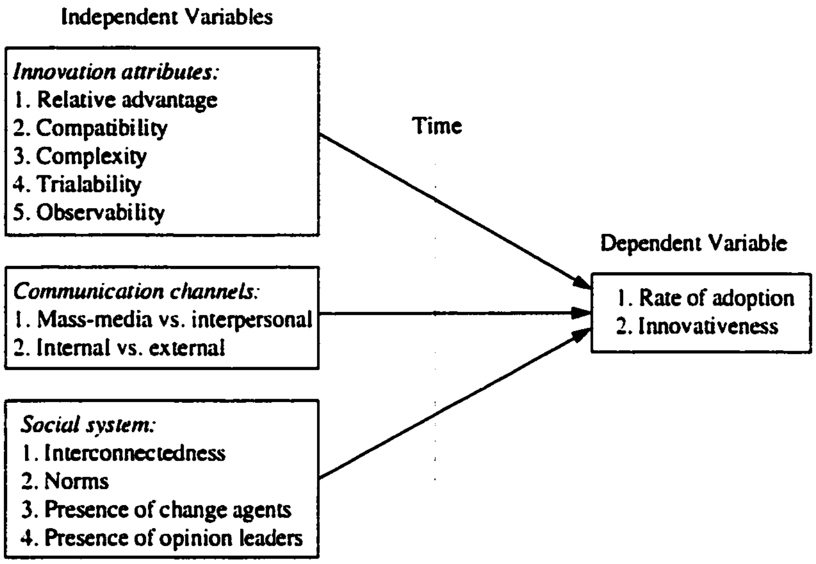

Figure 2.1 The classical innovation diffusion model (Rogers 1983)

Based on a synthesis of over 3000 articles, books, and assorted publications spanning five decades of diffusion research in over two dozen academic disciplines, the classical innovation diffusion model (Rogers 1983) posits that the diffusion of an innovation is patterned by a process of communication whereby a potential user is informed of the availability of the new technology by prior users within his/her social system and is persuaded to adopt it via a process of social influence. The cumulative distribution of adopters is hypothesized to follow a sigmoidal (S-shaped) curve: the diffusion process starts out slowly among a few adopters, followed by a "take-off" as adoptions breed other adoptions, finally leveling out as the number of adopters reaches saturation. As shown in Figure 2.1, the five major elements in this model are time, innovation (attributes), communication channels, social system, and the dependent variable. The dependent variable was addressed in Section 2.1.1; the remaining elements of this model are discussed below.

Time. The innovation diffusion model postulates that the behavior of potential adopters unfolds as a series of stages, from knowledge of an innovation, through persuasion, decision, implementation, and confirmation, similar to stage models of IT implementation. The time dimension is also captured in Rogers' (1983) classification of adopters as innovators, early adopters, early majority, late majority, and laggards.

Innovation Attributes. Rogers postulated that innovations possess certain attributes, which, as perceived by potential adopters, influence the rate and pattern of their adoption/usage. These attributes include: (1) *relative advantage:* degree to which an innovation is perceived as being better than the one it supersedes, (2) *compatibility:* degree to which it is perceived as being consistent with existing values, beliefs, and needs, (3) *complexity:* degree to which it is perceived as being relatively difficult to understand and use, (4) *trialability:* degree to which it may be experimented with on a limited basis, and (5) *observability:* degree to which the results of its use are visible to others.

Communication Channels. Channels that communicate information about an innovation to potential adopters can be categorized based on their source (internal versus external) and nature (mass-media versus interpersonal). Rogers contended that certain channels are more effective than others in influencing potential adopters, and their effects may vary depending on the stage in the diffusion process. External and mass-media channels are believed to have greater effects than internal and interpersonal channels in the initial stages of the diffusion process, and lesser effects in the later stages.

Social System. Interconnectedness and social norms, that affect communication of information within the adopter's social system, can influence his/her adoption behavior.

Similar effects can be rendered by the actions of certain individuals in the social system, such as change agents (persons who consciously attempt to influence others' innovation decisions toward a desired direction) and/or opinion leaders (individuals whose social position allows them to exert informal influence over others' attitudes or overt behavior).

Hypotheses drawn from Rogers' model, however, enjoy only limited support in the IT implementation/diffusion literature. Recent studies have questioned the generalizability of the S-shaped diffusion curve for IT innovations. While Brancheau and Wetherbe (1990) and Gurbaxani (1990) found support for the sigmoidal curve in the case of spreadsheet and BITNET diffusion respectively, Markus (1987) contended that the diffusion pattern of interactive media (e.g., electronic mail) is better represented by an exponential curve. Mixed results are also observed on the effects of innovation attributes (Goodwin 1987, Huff and Munro 1989) and communication-related variables (Brancheau and Wetherbe 1990, Nilakanta and Scamell 1990) on IT usage.

Some researchers argue that the simplicity of Rogers' model and its undue emphasis on innovation attributes are of little value in explaining the implementation of organizational innovations (e.g., Leonard-Barton 1987, Fichman 1992). They suggest that research efforts should instead focus on management procedures and strategies during the implementation process. Following a review of factors affecting implementation of office automation systems, Mankin, Bikson, and Gutek (1985) observed, "the specific technological characteristics of innovations are not as critical in successful implementation as the decisions, policies, change strategies, and resources within which the innovation is embedded ... the operating procedures, implementation behaviors, and user interactions are as important to the successful application of the machines as the machines themselves."

Fichman (1992) noted that Rogers' model yields conclusive findings only when the adoption context matches closely with that of the classical diffusion model, namely individual adoption of simple, personal-use technologies. One instance where this model fails is the case of intraorganizational IT adoption, where managerial influences may significantly impact on organizational members' IT usage behavior (Leonard-Barton and Deschamps 1988, Fichman 1992). Diffusion of organizational IT differs from that of individually adopted IT in that individual users rarely have complete autonomy regarding adoption and use of work place innovations, and management actions typically impact on individual decisions to use (or continue using) the IT. Management can encourage or discourage adoption explicitly through expressed preferences and mandates or implicitly through reward systems and incentives (Leonard-Barton and Deschamps 1988). In addition, supervisors typically control access to the infrastructure supporting adoption, such as training and physical access to hardware/software (Leonard-Barton 1987).

In summary, Rogers' (1983) model does not address issues related to managerial influences, and therefore has limited generalizability to intraorganizational contexts. The model developed in Chapter III accounts for this limitation by specifically examining the effect of two types of managerial influence, namely incentives and control, on organizational members' IT usage behavior. The proposed model is therefore expected to provide a more comprehensive understanding of intraorganizational IT usage that that accorded by prior diffusion models. By theorizing the relationship between managerial influence and individual usage, it provides a much needed linkage between macro-level managerial variables and micro-level individual variables and becomes more relevant for managers interested in better and more effective management of IT implementation/diffusion within their organizations.

2.2 Determinants of IT Usage

Of the different types of factors (individual, organizational, technological, task-related, and environmental) believed to affect IT usage, individual factors (e.g., beliefs, attitudes, and intentions) and organizational factors (e.g., management support and sponsorship) are of direct relevance to the current study. This is because this study is concerned with understanding how managers can influence individual user behavior (IT usage) within organizations. The relevance of individual factors was made evident by Srinivasan and Davis (1987): "the centrality of users and the critical roles played by them are increasingly obvious in contemporary IS environments;" while the importance of managerial factors was highlighted in Ginzberg's quote (1981b): "an individual's response to the introduction of an IT is highly colored by the way in which the organization's managers orchestrate the IT context." This section, reviews the current body of knowledge regarding the effect of these factors on IT usage. The purpose is to identify areas that may benefit from further research and to demonstrate how the current study can help address these shortcomings.

2.2.1 Individual Factors

Following an extensive review of individual differences research, Zmud (1979) identified three categories of individual factors of potential relevance to IT usage research: cognitive style, personality/attitudes, and demographic/situational variables. Cognitive styles refer to the characteristic (habitual) ways individuals process and utilize information in their problem-solving and decision-making behavior, such as whether they utilize abstract models and systematic processes in cognition or whether they are guided by experience and common sense (Huysman 1970). Two assumptions underlying this stream of research are: (1) systematic differences in individual perception, thinking, and judgment influence a person's choice and use of IT, and (2) differences in cognitive styles of IT developers and users may explain difficulties in implementation success. Though cognitive style represented a major stream of MIS research in the 1970's (e.g., Bariff and Lusk 1977, Dickson, Senn, and Chervany 1977, Benbasat and Taylor 1978), empirical findings were mostly conflicting and explained less than ten percent of the total variance (Huber 1983). Extensive critiques have been leveled against the methodological weaknesses and lack of usefulness of this line of research (e.g., Taylor and Benbasat 1980, Huber 1983). In particular, Huber (1983) concluded, "(1) the currently available literature on cognitive style is an unsatisfactory basis for deriving operational design guidelines, and (2) further cognitive style research is unlikely to provide a satisfactory body of knowledge from which to derive such guidelines," which subsequently led to a gradual demise of interest in this area.

Personality/attitudinal factors relate to cognitive (beliefs about persons, objects, or events), affective (feelings such as fear, anxiety, and satisfaction), and conative (intentions to behave in a certain way) structures of individuals that are manifested in their observed behavior (Hilgard 1980, Breckler 1984). While personality represents long-term stable traits that are developed early in life and remain unchanged over a broad spectrum of situations, attitude is a temporary predisposition towards a particular object or event and may change across time and situations (Ajzen and Fishbein 1980). Following a summary of nine empirical studies on IT implementation, of which six included attitude as an independent variable, Lucas (1975) observed, "Attitudes and perceptions [of users] are expected to influence the use of a system; attitudes have a behavioral component, and favorable attitudes are consistent with high levels of use of a system." Other empirical research also indicate strong positive association between user attitudes and IT usage (e.g., Lucas 1975, Ginzberg 1981b, Davis, Bagozzi, and Warshaw 1989, and Igbaria 1989), while only limited support is found for personality variables such as locus of control, dogmatism, and extroversion/introversion (Alavi and Joachimsthaler 1992). Moreover, attitude-based instruments tend to account for more variance in individual behavior compared to personality-based instruments; typical correlations are around 0.4-0.7 for attitude and 0.1-0.3 for personality (Ajzen and Fishbein 1980). While personality traits may explain individual behavior over a wide range of contexts, the domain specificity of attitude-based instruments makes them more useful in predicting behavior in specific contexts such as IT usage (Ajzen and Fishbein 1980).

Demographic variables cover a broad spectrum of personal characteristics such as age, education, and experience (Zmud 1979), while situational variables include user training and user involvement during system development (Alavi and Joachimsthaler 1992). Empirical evidence indicates that education and prior experience with IT are positively related to users' attitudes and hence to IT usage (Guthrie 1973, Lucas 1978, Brancheau and Wetherbe 1990). Experience may also have a moderating effect on IT use in that experienced users are less likely to change their attitudes toward IT and are less affected by external influences such as management support (Leonard-Barton and Deschamps 1988). Of the situational variables, Ives and Olson (1984) found that user involvement has only mixed associations with attitude, IT usage, and user satisfaction.

Of the different categories of individual variables, only attitudinal factors are found to be consistently related to IT usage, accounting for approximately 30 percent of the variance in usage (Davis, Bagozzi, and Warshaw 1989). Certain demographic/situational variables (e.g., experience and education) are also associated to IT usage, but such relationships are mediated by user attitudes. However, as indicated by a meta-analysis of the implementation literature (Alavi and Joachimsthaler 1992), a large proportion of the variance in IT usage still remains unexplained. Examination of the relative magnitude of effect sizes in this study led the authors to conclude that managers can improve implementation success by as much as 30 percent by effective management of organizational members' attitude toward IT use. The next section discusses findings that relate managerial influence to intraorganizational IT usage.

2.2.2 Managerial Factors

Organizational factors believed to affect IT usage can be grouped into two categories: structural factors such as centralization, formalization, specialization, interconnectedness/communication, and organizational slack; and managerial factors, such as management support and attitude toward change (Zaltman, Duncan, and Holbek 1973, Rogers 1983). Examining the literature linking structural factors and IT usage, Cervany and Sanders (1986) concluded that there are a preponderance of assertions and propositions with little empirical support confirming the effects of these variables on IT usage. Furthermore, research in this area has been of little normative value in designing strategies for IT implementation since manipulating structural factors typically requires substantial organizational resources, which are often not justified in the short-run. This review is therefore concerned with research on managerial factors only.

Managerial factors examined in the IT implementation/diffusion literature include management support, management's attitude to change, user training, and project planning. Empirical research indicates that management support/sponsorship has a strong positive association with IT usage (Lucas 1978, Maish 1979, Ginzberg 1981b, DeLone 1988). El Sawy (1985) cited the example of a database management system that failed due to the absence of a key support person to sustain the implementation effort. Zmud and Cox (1979) noted, "Personnel tend to accept such change [IT implementation] only if they perceive their superiors to be supportive of the change." Lucas (1978) observed that management support not only has a direct effect on implementation success, but also affects usage indirectly by influencing user attitudes toward the IT. Similar findings are reported by Leonard-Barton and Deschamps (1988), who found that managerial influence is not perceived equally by all organizational members; while experienced users are less influenced by managerial actions in their IT usage behavior, novice users typically await managerial directives before committing to usage.

While management support is touted as an important determinant of IT implementation success, little if any research has examined precisely what kind of management support is most effective and under what circumstances. The rationale for the direct and/or mediating effects of managerial influence on intraorganizational IT usage is also quite unclear. The next section summarizes the shortcomings in our current state of knowledge in this area and describes how the current study proposes to address these limitations, and thereby further our knowledge in this area.

2.2.3 Summary

The above review indicates that IT usage within organizations depends not only on individual factors but also on managerial actions (Chakrabarti 1974, Leonard-Barton and Deschamps 1988). DeSanctis (1984) distinguished between research focusing on individual versus managerial factors as the micro versus macro perspective of IT implementation research. With few exceptions (e.g., Leonard-Barton and Deschamps 1988), most implementation research to date has adopted either a micro (individual) or a macro (organizational) view of IT implementation, with little attention to the interaction between these views. Yet, a complete understanding of IT implementation/diffusion requires an integration of micro and macro perspectives.

The need to integrate micro and macro level variables within a comprehensive framework also has been urged by many prior IT implementation/diffusion researchers (e.g., Kwon and Zmud 1987), however little has been done to that effect. DeSanctis (1984) contends that mixed level research is most appropriate in this area since implementing IT within organizational settings is neither strictly micro nor macro in nature. DeSanctis claims that causal linkages should be sought between individual attitudes/intentions and managerial influences in order to further our knowledge of IT implementation/diffusion. The model of intraorganizational IT usage proposed in this study provides this integration by examining how individual intentions are affected by managerial influences in form of incentives and control structures.

In addition, much of the existing research in IT implementation is poorly grounded in theory (Ives and Olson 1984, Kwon and Zmud 1987). Research has mostly been directed at identifying "what" factors are related to implementation, rather than explaining "why" or "how" they affect implementation processes or outcomes (Cooper 1988). Knowing what factors affect the dependent variable is of little use in generating normative guidelines for better management of the implementation process or in predicting the success of an implementation effort, unless one can explain why and how these factors relate to the desired outcomes. Theory-based research can not only help identify a parsimonious set of "important" variables worthy of research, but also improve the strength of causal linkages between research variables, and is therefore essential for the conduct of purposeful scientific inquiry in this area (Steinfeld and Fulk 1987). The next section examines some of the theories of potential relevance to the IT usage problem.

2.3 Theories of IT Usage

This section reviews three theories of IT usage, namely the theory of reasoned action (Fishbein and Ajzen 1975), the technology acceptance model (Davis, Bagozzi, and Warshaw 1989), and the theory of planned behavior (Ajzen 1991), in an effort to understand how some of the factors identified in the previous section may or may not be related to the dependent variable. Rooted in the expectancy theoretic traditions of social psychology, these theories explain IT usage in terms of individual beliefs, attitudes, and intentions toward the intended behavior. As argued in this section, the proposed model of intraorganizational IT usage can potentially extend these individual use theories to an organizational context by accounting for the role of managerial influences on individual IT usage behavior.

2.3.1 Theory of Reasoned Action

The theory of reasoned action (TRA) is a general theory about human behavior developed by Fishbein and Ajzen (1975), which holds that individual behavior (e.g., IT usage) is predicted by his/her intention to perform that behavior, which in turn, is determined by a weighted combination of the person's attitude toward the behavior and his/her subjective assessment of the social acceptability of such behavior (see Figure 2.2). While attitude is a consequent of the individual's beliefs regarding the behavior (behavioral beliefs), social acceptability or subjective norm is determined relative to the opinions of his/her referent group (normative beliefs). Individual behavior can therefore be modified by influencing his/her behavioral and/or normative beliefs. TRA does not specify what beliefs are operative for a certain behavior, but acknowledges that "external variables" may affect a person's behavior by influencing his/her attitudes, subjective norms, and/or their relative weights.

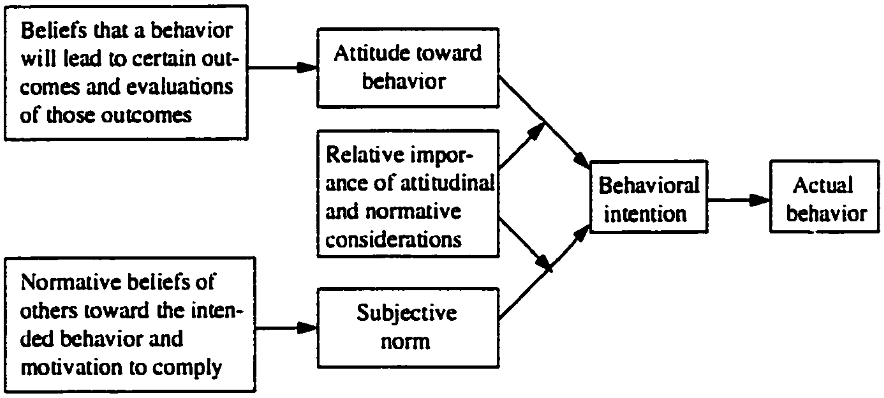

Figure 2.2 Theory of reasoned action (Fishbein and Ajzen 1975)

Empirical work in social psychology indicates strong overall support for the predictive utility of TRA (e.g., Ajzen and Fishbein 1980, Sheppard, Hartwick, and Warshaw 1988). However, within the IT implementation context, Davis, Bagozzi, and Warshaw (1989) found that although TRA was useful in predicting intentions to learn to use a word processing package, the subjective norm component did not have a significant contribution toward that prediction. This led the authors to propose a modified version of TRA called the technology acceptance model (TAM), specifically tailored to the IT usage context, which is described in the next section.

2.3.2 Technology Acceptance Model

The technology acceptance model (TAM), one of the most widely cited models of IT usage in the implementation literature, is an adaptation of the TRA specifically suited for explaining individual IT usage behavior (Davis, Bagozzi, and Warshaw 1989). According to its authors, "The goal of TAM is to [be] ... capable of explaining user behavior across a broad range of end-user computing technologies and user populations, while at the same time being both parsimonious and theoretically justified" (p. 985). TAM excludes the subjective norm component of TRA because of "its uncertain theoretical and psychometric status" (Davis, Bagozzi, and Warshaw 1989, p. 986), and holds that two perceptual belief sets, namely usefulness and ease of use, are of primary relevance in determining individual attitude toward IT usage and their consequent behavior (see Figure 2.3). In addition, TAM reported empirical associations between usefulness and ease of use and between usefulness and behavioral intention, that were not theoretically justified.

Similar to other expectancy theories, TAM emphasizes both behavioral beliefs and perceptual weights attached to those beliefs. For a sales representative using a notebook computer to access a centralized inventory database from remote sites, a potential outcome of computer usage might be improved customer service, while a behavioral belief would refer to the extent to which the salesperson believes that using the computer will improve customer service. Because behavioral beliefs and outcome evaluations are multiplied, the salesperson's attitude would be affected most if the salesperson believes that the system would improve customer service and also considers improving customer service as being important (Mathieson 1991).

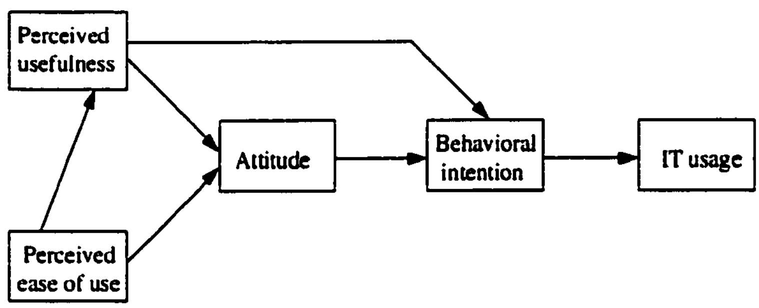

Figure 2.3 Technology acceptance model (Davis, Bagozzi, and Warshaw 1989)

Predictions based on TAM were supported in a study involving the use of a word processing package by MBA students (Davis, Bagozzi, and Warshaw 1989), and in a later replication study of voice mail and electronic mail use by subscribers of a telephone company (Adams, Nelson, and Todd 1992). Though TAM works reasonably well in predicting individual usage of IT independent of organizational contexts, its omission of the subjective norm component limits its generalizability to settings where the presence of referent groups can have a significant influence on individual usage behavior. In an organizational setting, managers may constitute one such powerful referent group whose direct or indirect influences may have a significant impact on organizational members' IT usage behavior. The principal-agent model of intraorganizational IT usage proposed in the next chapter attempts to formalize the role of managerial influence in affecting individual behavior, and thereby extends TAM to organizational contexts.

2.3.3 Theory of Planned Behavior

The theory of planned behavior (TPB), proposed by Ajzen (1985, 1991) is an extension of TRA to circumstances where individuals do not have complete control over their behavior (see Figure 2.4). It holds that intention regarding a certain behavior is determined by three factors: attitude (degree of favorableness or unfavorableness toward the intended behavior), subjective norms (perceptions of significant referents' opinions regarding the behavior), and perceived behavioral control (perceptions of internal or external constraints affecting the behavior); which in turn are governed respectively by three underlying belief structures: behavioral beliefs, normative beliefs, and control beliefs. Actual behavior is hypothesized to be governed by both behavioral intention and perceived behavioral control. While the attitude and subjective norm components are taken from TRA, perceived behavioral control is unique to TPB and is a function of control beliefs and perceived facilitation (Ajzen and Madden 1986). While control beliefs refer to individual perceptions of the availability of skills, resources, and opportunities needed to perform a behavior, perceived facilitation represents the individual's assessment of the importance of these resources to the achievement of the desired outcomes.

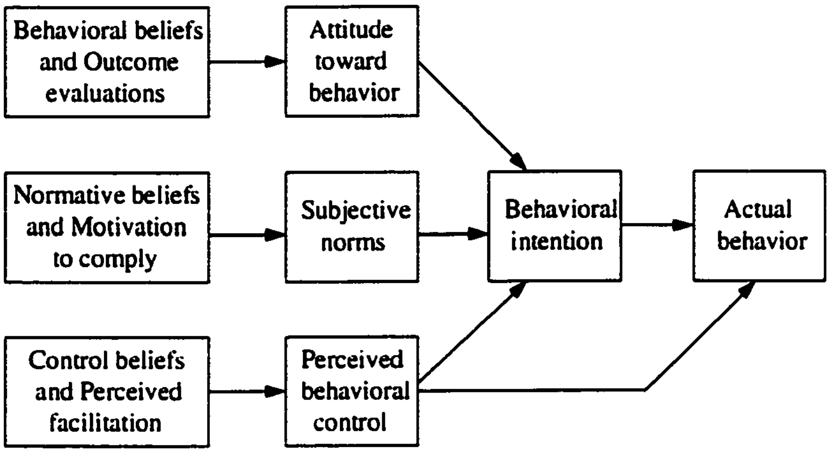

Figure 2.4 Theory of planned behavior (Ajzen 1985)

Mathieson (1991) notes that control beliefs can be situational (e.g., having access to the intended IT) as well as personal (e.g., being able to use an IT or self-efficacy), and therefore, TPB goes beyond TAM's ease of use construct to embrace other barriers to IT usage. For instance, in the previous salesperson example, if the notebook computer requires access to a telephone line to connect to a central mainframe, and the salesperson is visiting sites where telephone lines are not available, his/her perceived behavioral control over the usage of notebook computer will be low, which may discourage him/her from using the IT. Control beliefs, however, is beyond the scope of the current study.

In addition, TPB may capture unique variance in IT usage due to social variables such as organizational controls (e.g., monitoring) and/or motivational tools (e.g., incentives) via its subjective norm construct, that are not accounted in TAM (Taylor and Todd 1995). The model of intraorganizational IT usage presented in the next chapter captures this notion of management control and incentives, and posits that managers can enhance IT usage by designing strategies to improve normative beliefs of organizational users, and thereby provide them with a motivation to use IT appropriately.

2.4 Summary

This chapter reviewed prior research in IT implementation and diffusion relevant to the study's interest in intraorganizational IT usage. The review indicates that though most research in these areas has been historically conducted from different perspectives, there exists a considerable degree of overlap across the two literatures. The commonalties between the implementation and diffusion research streams are used in this chapter to first define IT usage as the dependent variable for the current study, and then to outline the scope of the current study using a two-dimensional framework of implementation/diffusion research (based on the type of factors and implementation stages addressed). Shortcomings of Rogers' (1983) innovation diffusion model in understanding intraorganizational IT usage are also highlighted.

A review of factors research in IT implementation/diffusion indicates that certain individual factors (e.g., attitudes, beliefs) and managerial factors (e.g., management support) exhibit consistent associations with IT usage. Organizational members' utilization of IT depends not only on their beliefs, attitudes, and intentions, but also on management's opinions, strategies, and actions (Alavi and Joachimsthaler 1992). However, to date, little effort has been devoted toward analyzing the interaction between these factors, i.e., little is known about how managers can influence individual users' attitudes and actions toward a desired direction. There is also a need to integrate micro-level individual variables with macro-level managerial variables in order to develop a more comprehensive understanding of IT usage.

The normative value of IT implementation/diffusion research lies in its ability to prescribe strategies that can be employed by managers to enhance IT usage within their organizations. Unfortunately, prior research has been of little managerial relevance. The current research brings to the forefront the important issue of managerial incentives and control, that has been mostly overlooked in prior implementation/diffusion research. In doing so, it describes what type of incentives and/or control structures are effective in motivating IT usage among organizational members and under what circumstances.

For progress to be made in developing a coherent body of knowledge in any area, it is necessary to conduct theory-based research that can help understand the underlying causative mechanisms behind empirically observed associations. To date, theorizing in IT implementation/diffusion research has been based primarily on theories from cognitive psychology such as TRA, TPB, and TAM, that attempt to explain usage based on individual-level variables such as beliefs and attitudes. However, these theories do not address how these variables can be manipulated by managers in organizational settings, and therefore have limited generalizability to organizational contexts. The principal-agent model (PAM) of intraorganizational IT usage proposed in the next chapter addresses this issue by theoretically linking managerial influence related to incentives and control to IT usage. Agency theory in the microeconomics literature is employed for that purpose. As explained in Chapter III, PAM is an adaptation of TPB and an extension of TAM to organizational contexts, that accounts for the effect of managerial influences on individual IT usage within organizations.

Chapter III

THEORETICAL MODEL

The current study focuses on an area that has been largely ignored in prior IT implementation/diffusion research, namely the effect of managerial incentives and control on individual IT usage behavior. By drawing on principal-agent research in the microeconomics literature, this chapter explains why and how managerial incentives can motivate IT usage by organizational members, identifies potential conflicts in implementing these incentives, and suggests control structures that can help overcome such conflicts. Principal-agent constructs are incorporated within a theory of planned behavior (Ajzen 1985, 1991) framework to develop a principal-agent model of intraorganizational IT usage. The proposed model is not only more comprehensive than prior usage models, but is also generalizable to organizational contexts.

This chapter proceeds as follows. It begins with a discussion on the need for theory-based research in organizational studies and the relevance of agency theory to the current research problem. This is followed by a general overview of the principal-agent model (PAM), which constitutes the underlying theoretical basis for this study. Section three maps the generic PAM to the specific case of intraorganizational IT usage and then develops an principal-agent model of IT usage by adding PAM constructs within a TPB framework. Section four examines prior empirical research in IT implementation/diffusion to derive support for the proposed model. Section five revisits PAM assumptions in order to assess the generalizability of the proposed model to different organizational settings. The chapter ends with a summary of the preceding sections.

3.1 Theoretical Background

This section presents a brief background of principal-agent research, the underlying theoretical basis for this study. It is organized in two parts. The first part summarizes the role of theorizing in IT usage research and in the study of organizations in general. This is followed by a brief background of agency theory and organizational economics, an emerging branch of microeconomics to which agency theory belongs and a discussion on why this theory is considered appropriate for the current research problem.

3.1.1 Role of Theorizing in Research

A theory can be defined as "a statement of relations among concepts within a set of boundary conditions and constraints" (Bachrach 1989). It is essentially a set of law-like propositions that interrelate constructs or variables two or more at a time. Theories are important in the study of organizational phenomenon (e.g., IT usage) for four reasons.

First, a theory provides a framework for integrating prior research by systematically synthesizing empirically deduced relationships into a coherent whole. By providing a perspective on broadly based knowledge claims, it helps us see the forest as well as the trees (Blalock 1968). Second, a theory helps reconcile contradictory findings, by providing the underlying rationale governing hypothesized associations among research variables (Steinfeld and Fulk 1987). Third, a theory provides guidance for future research by directing our attention to substantive organizational issues worthy of research, by identifying "important" constructs and associations, and by deriving a priori hypotheses for empirical testing (Steinfeld and Fulk 1987). Finally, a theory contributes to cumulative knowledge building by bridging gaps between two or more well-established theories and/or causing existing theories to be reevaluated in a new light (Kaplan 1964).

Agency theory in the microeconomics literature is employed in this research to develop a model of intraorganizational IT usage that can help explain the role of managerial influences (i.e., incentives and control) in motivating organizational members' use of IT. Not only does the proposed model directs our attention to a topic which has eluded the attention of most IT implementation/diffusion researchers, but also has an epistemological contribution in that it extends current models of IT usage (e.g., TAM) from personal-use contexts to organizational contexts. In addition, the theory suggests constructs and relationships that can be examined in subsequent empirical research.

3.1.2 Agency Theory

Agency theory belongs to a new class of theories about the economic organization, called *organizational economics* (Barney and Ouchi 1986, Donaldson 1990), that emerged from the general body of microeconomics research in the late 1970's. These new theories build on Coase's (1937) ideas that markets and firms are alternative ways of organizing economic exchanges and that uncertainty and opportunism sometimes make it costly for the market-based price mechanism to coordinate economic activity. While traditional microeconomic theories (e.g., production theory) view all economic transactions as market exchanges or some variant of it and rule out departures from market exchange as "market failures," these new theories argue that non-market forms of economic transactions, including complex forms of contracting, not only exist but are sometimes more efficient than corresponding market forms (Nilakant and Rao 1994).

Organizational economics views organizations as "legal fictions which serve as a nexus for a set of contracting relationships among individuals" (Jensen and Meckling 1976, p. 310). Most research in this area has centered on two broad theoretical camps, namely agency theory and transaction cost theory, both of which utilize a contractual framework in analyzing organizational behavior. *Agency theory* (Jensen and Meckling 1976, Fama 1980) deals with ex ante design of contracts that would safeguard all organizational members against possible contingencies. It argues that cooperative effort within organizations is plagued by opportunistic behavior by organizational members and that incentive systems and formal control mechanisms should be used to mitigate problems associated with such behavior. On the other hand, *transaction cost theory* (Williamson 1979, 1981) focuses on ex post implementation of contracts, attempting to identify governance mechanisms (e.g., markets and hierarchies) that can minimize a combination of production and transaction costs (the costs of creating and enforcing contracts) (Nilakant and Rao 1994).

Despite controversy regarding some of its assumptions (Perrow 1986, Robins 1987, Donaldson 1990), agency theory has been touted as "the foundations for a powerful theory of organizations ... a major advance beyond the usual sociological methods of organizational analysis" (Jensen 1983, p. 324). Proponents of agency theory claim that it has the potential of improving the rigor in organization studies by encouraging theorists to build systematic theoretical models from general axioms of social behavior (Robins 1987). Gurbaxani and Kemerer (1990, p. 279) pointed out the relevance of agency theory in MIS research as, "While traditional microeconomics has proven useful in analyzing a large variety of problems, it has not been widely used in analyzing intrafirm managerial control problems due to its assumptions of costless information transfer and goal congruence ... Agency theory extends the microeconomic approach by relaxing these assumptions and, therefore, will be particularly appropriate for studying intrafirm control problems."

Organizational problems analyzed using agency theory include executive compensation, acquisition and divestiture strategies, ownership and financing structures, and vertical integration (Eisenhardt 1989). It is our intent to demonstrate that this theory can also provide a satisfactory basis for understanding and predicting individual IT usage within organizations.

Research on agency theory has progressed along two parallel but complimentary lines: positivist agency research and principal-agent research. Both streams treat contracts as the unit of analysis and share common assumptions about people and organizations; however, they can be distinguished based on their focus, mathematical rigor, and style of analysis (Eisenhardt 1989, Nilakant and Rao 1994). *Positivist agency research* is concerned with the broad problem of separating stakeholders (principals and agents) with incongruent goals and identifying alternative contracts that can limit agents' self-serving behavior, while *principal-agent research* takes contracts as given, attempts to understand problems that arise in enforcing these contracts, and suggests ways to remedy them. While positivist agency research focuses on the principal's decision process, principal-agent research is directed at understanding the agent's decision process. Also, positivist agency research has been largely non-mathematical in its formulation and has drawn greater attention among organization scholars, while principal-agent research is relatively more mathematical and abstract, involving logical deduction and mathematical proof, and has been less utilized in organizational studies (Eisenhardt 1989). As discussed later in this chapter, the current study is concerned with understanding the user's (i.e., agent's) decision process in a management-user relationship, and therefore belongs to the principal-agent stream of research.

The next section examines the theoretical ideas of principal-agent research, which forms the underlying basis for an intraorganizational IT usage model proposed in Section 3.3.

3.2 The Principal-Agent Model

The principal-agent model (PAM) attempts to describe the behavior of two parties involved in a business relationship, where the payoffs of one party (the principal) depend on the actions of the other (the agent). Typical examples of such relationships include employer-employee, shareholder-manager, buyer-supplier, and so forth (Harris and Raviv 1979). The principal owns the means of production but does not possess the time or the ability to produce the desired output, and therefore hires an external agent to perform the task on his/her behalf. However, agents often act in a manner inconsistent with the interests of the principal, resulting in an agency problem. PAM attributes this agency problem to three reasons: (1) *goal incongruence:* the goals of the agent do not necessarily coincide with that of the principal, (2) *information asymmetry:* the principal cannot perfectly or costlessly observe the agent's actions (moral hazard) and/or private information (adverse selection), and (3) *risk aversion:* the agent is typically risk-averse and may therefore shirk from risky behaviors. PAM attempts to resolve the agency problem by suggesting incentives and control structures (e.g., monitoring) that can motivate the agent to behave in the principal's best interests (Arrow 1985, Sappington 1991).

The typical sequence of events in a simple principal-agent model is as follows (Sappington 1991). The principal designs a contract, specifying incentives to be awarded to the agent for different possible outcomes. The agent decides whether to accept or reject this contract, and in case the contract is rejected, the relationship is terminated. If the agent accepts the contract, he/she observes a "state of nature" (i.e., one or more exogenous variables, such as task-related information, that are unpredictable and outside the control of either party) and decides how much effort to put forth. The agent's decision is influenced by three factors: (1) amount and type of incentives offered by the principal, (2) effort required to perform the task, and (3) the agent's observation of the state of nature. While incentives provide utility to the agent, effort incurs disutility (negative utility), and the state of nature mediates the effect of effort expended on the realized outcomes. Given these factors, the rational agent selects an effort level that maximizes his/her payoffs. The principal cannot see or infer the actual effort expended by the agent but observes the realized outcomes, based on which he/she rewards the agent as promised in the contract.

Table 3.1 Key ideas in the principal-agent model

Nature of problem	Relationship between two parties (principal and agent) having partially incongruent goals
Decision problems	Principal: To identify what form of incentives will make the agent behave in the best interests of the principal Agent: To determine an effort level for given incentives, beliefs about required effort, and state of nature
Assumptions	Human: Self-interest, Bounded rationality, Risk aversion Organizational: Goal incongruence, Information asymmetry, Production efficiency
Sources of conflict (ways to mitigate them)	Goal incongruence (presence of incentives) Risk aversion (behavior-based incentives) Moral hazard (monitoring) Adverse selection (multiple agents, repeated contracts)

The key ideas of PAM are listed in Table 3.1. The goal of PAM is to suggest optimal incentive schemes that the help the principal in motivating the agent to expend the desired effort, and to identify conditions under which such incentives would be effective.

In doing so, PAM makes certain assumptions about people and organizations. It assumes that human beings (both principals and agents) are motivated by self-interest, boundedly rational (i.e., they exhibit utility-maximizing behavior, but only within certain boundary conditions), and risk-averse. Organizations, on the other hand, are characterized by goal incongruence (i.e., the goals of organizational members may conflict), information asymmetry (i.e., agents have better information about their behavior and perceptual beliefs than principals), and production efficiency (i.e., organizational outcomes vary directly with the quantity of behavior expended because the quality of behavior is always acceptable). These assumptions are discussed at length in Section 3.5 of this chapter.

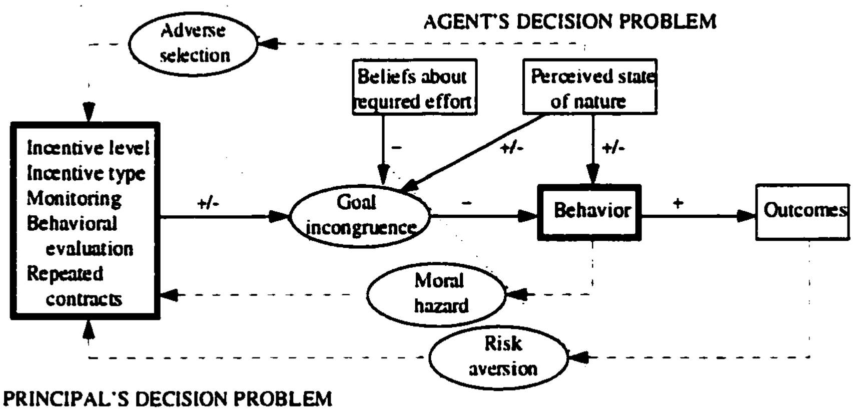

Figure 3.1 The principal-agent model

The different components of the principal-agent model are illustrated in Figure 3.1. In this figure, the decision domains of the two parties are represented by dashed trapezoids, while potential sources of conflict are indicated by ellipses between these trapezoids. The solid arrows represent the agent's line of reasoning, and the dashed arrows reflect the reasoning of the principal. Decision variables taken into consideration by either party are indicated by rectangles. The two heavy rectangles represent the decision problems of the two parties: the principal is concerned with designing ex ante incentive schemes that can minimize agency costs (costs incurred by the principal in motivating, monitoring, and ensuring the commitment of the agent), while the agent is concerned with selecting an effort level that maximizes his/her utility for given incentive schemes, effort requirements, and state of nature. As such, PAM equates the design of contracts to reconciling the agent's utility maximization problem and the principal's cost minimization problem (Nilakant and Rao 1994). The current study focuses solely on the agent's decision problem.

At the heart of PAM is the notion of goal incongruence between the principal and agent. Support for goal incongruence among organizational members comes from March and Simon (1993), who claim, "task performers typically place greater emphasis on individual goals than common group goals." PAM posits that incentives provided by the principal can help reduce goal incongruence, and thereby motivate the agent to act in the best interests of the principal. Such incentives may vary depending on their level (low versus high) and/or type (incentives based on the agent's behavior versus those based on the outcomes of such behavior) (Ouchi 1979). Specifically, PAM looks at the relative merits of behavior-based incentives (e.g., salaries) versus outcome-based incentives (e.g., commissions), and examines circumstances when one may be more effective compared to the other (Eisenhardt 1989).

The agent's attitude toward risk can also influence his/her behavior, particularly if the behavior entails a high degree of risk. Most agent behaviors are risky since the outcomes of such behavior are largely unpredictable and outside the agent's control (Eisenhardt 1989). At the same time, agents may differ in their extent of risk aversion, defined as a psychological disposition toward risky situations in general that are encoded as a part of the individual's personalities and are independent of any specific behavior and/or context (Kagel and Roth 1995). PAM holds that risk averse agents will tend to shirk from behavior that involves a greater degree of risk. Also, outcome-based incentives that transfer additional risks to the agents by making them accountable for the uncertain outcomes, may be resisted by such agents. Under such circumstances, the principal will have little alternative but to offer behavior-based incentives, as is typically the case in many organizations (Eisenhardt 1989).

The design of behavior-based incentives in principal-agent relationships is complicated by the principal's lack of knowledge about the agent's actual behavior and/or perception of the state of nature. These information are, however, known to the agent, resulting in information asymmetries, which may be used by the agent to indulge in opportunistic behavior. Two information asymmetry problems discussed widely in the principal-agent literature are that of hidden action and hidden information, more commonly called the moral hazard and adverse selection problems (Arrow 1985).

The *moral hazard* problem refers to the principal's ignorance about the actual behavior (effort) level expended by the agent. Effort brings disutility to the agent, but is of value to the principal, since it increases the likelihood of favorable outcomes. Though the principal can observe the outcomes of the agent's behavior, the behavior itself may not be observed or inferred. Opportunistic agents may take advantage of this information asymmetry to set their efforts at lower levels. For example, a salesperson provided with a notebook computer to help in his/her sales activities (e.g., checking inventory, recording sales transactions) in remote areas may tend to utilize the computer less if he/she knows that his/her actual usage of the computer cannot be determined by supervisors.

In the *adverse selection* problem, the agent makes some observation, typically regarding the state of nature, which is not available to the principal. This private information may be utilized in the agent's choice of behavior, but is not accounted in the principal's design of incentives, leading to the design of ineffective incentives. In the previous example, if the salesperson knows that he/she will not have access to telephone lines for connecting his notebook computer to the corporate mainframes in certain sales regions, he/she will tend to utilize the computer less despite the presence of incentives.

Three control mechanisms are suggested in the principal-agent literature to overcome problems associated with information asymmetries (Nilakant and Rao 1994). The moral hazard problem may be remedied in part by employing monitoring mechanisms that provide the principal with some information about agent behavior, while the adverse selection problem can be mitigated by designing incentives based on the agent's behavior relative to that of other agents or relative to his/her own behavior in other time periods. Monitoring mechanisms, such as computer logs, time sheets, and spot checks by supervisors, may be useful in curbing user opportunism because they are perceived by agents as revealing their behavior to the principal, thereby inducing them not to "cheat" the principal with the promised effort level (Sappington 1991). Likewise, in a multiple-agent setting, evaluation of an agent's behavior relative to his/her peers can help control for states of nature common to all users albeit unknown to principal. In a multiple-period setting, if an agent's incentive in the current period is tied to his/her behavior in future periods, the agent will be motivated to perform the behavior in the current period in order to improve his/her chances of obtaining favorable contracts in future periods (Eisenhardt 1989). These ideas are explored in greater detail in the next section within the context of intraorganizational IT usage.

3.3 A Model of Intraorganizational IT Usage

Intraorganizational IT usage can be modeled in the form of a principal-agent relationship, by viewing management as principal and individual users as agents. Managers acquire IT to achieve organizational benefits, such as reduction in inventory costs or improvements in decision making (outcomes), and want users to utilize the IT appropriately (behavior) so that the intended benefits are realized (Leonard-Barton and Deschamps 1988). However, individual users typically value their personal goals over management goals (Francik, Rudman, Cooper, and Levine 1991), hence the conflict of interests. Appropriate IT usage often requires users to expend effort in overcoming usage barriers such as learning curves (Attewell 1992) and/or social inertia (Keen 1981), and may therefore be resisted by users (Markus and Robey 1988). PAM holds that managers can induce organizational members to utilize the IT appropriately by providing them with incentives (e.g., commissions, promotions, praise) for such use and/or penalties (e.g., threats, dismissals) for non-use. Organizational members decide on their level of IT usage based on the availability and type of incentives, effort required to utilize the IT, and environmental variables (state of nature) affecting IT usage (e.g., IT accessibility). The mapping between PAM and the intraorganizational usage problem is depicted in Table 3.2.

Table 3.2 Structural similarities between PAM and intraorganizational IT usage

Principal-agent model	*Intraorganizational IT usage*
Principal	Management
Agents	Individual users
Contract	Incentives offered by management for appropriate use
State of nature	Environmental variables affecting IT usage
Behavior	Appropriate IT usage by individual users
Outcome	Organizational effectiveness from using IT

Given that this dissertation focuses on intraorganizational IT usage, users' behavior is of interest to this study rather than the outcomes of such behavior. However, both behavior-based and outcome-based incentives were employed in order to compare the relative effect of the two incentives types on the intended behavior (i.e., appropriate IT usage). The outcomes of this behavior, despite being an important research topic in IT implementation, is therefore beyond the scope of the current IT usage model.

The remainder of this section develops a principal-agent model of intraorganizational IT usage by linking key PAM constructs (e.g., incentive type, risk aversion, etc.) with intraorganizational IT usage (agent behavior) within the theory of planned behavior

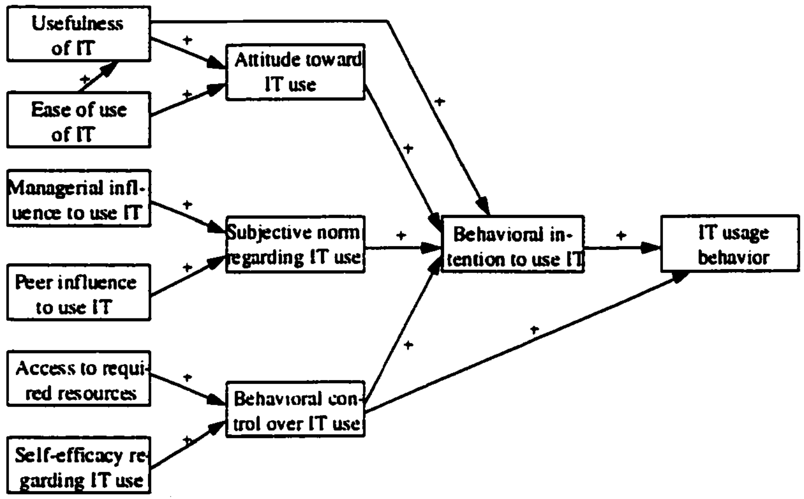

Figure 3.2 A TPB model of IT usage (augmented with TAM)

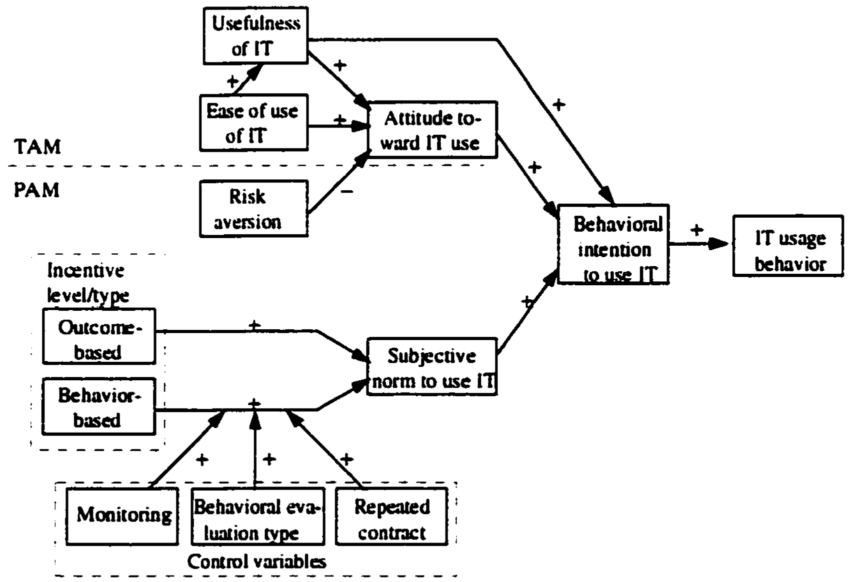

Figure 3.3 A principal-agent model of intraorganizational IT usage

(Ajzen 1985, 1991) framework. TPB, illustrated in Figure 3.2, is a general framework of human behavior which can be utilized to explain IT usage (e.g., Mathieson 1991, Taylor and Todd 1995). PAM can be used to help understand the attitude and subjective norm components of this framework. PAM has very limited contributions regarding the behavioral control component of TPB, and hence behavioral control is left out from subsequent analysis. The modified TPB, including PAM constructs, is depicted in Figure 3.3, and will henceforth be referred to as the TPB framework.

Intraorganizational IT Usage

As discussed in Chapter II, a considerable volume of research in IT implementation/diffusion has been directed at understanding IT usage within organizations. From an organizational standpoint, managers are generally not interested in IT usage by organizational members unless such usage contributes to organizational goals. Achievement of goals is related to "appropriate" usage rather than usage in general. For instance, playing computer games or internet surfing may contribute to increased computer usage on the part of an organization's salespeople, but such usage may not contribute to increased sales. Therefore, intraorganizational IT usage was defined in this study in terms of the appropriateness of use.

Furthermore, intraorganizational IT usage may refer to the breath of use by organizational members, such as number of users utilizing the IT or number of tasks in which IT is used (e.g., Fuerst and Cheney 1982, Brancheau and Wetherbe 1991), and/or the depth of use, such as number of functions within the IT utilized by a single user or number of times the IT is used per task (e.g., Ginzberg 1981a, Srinivasan 1985). Each interpretation of usage has its advantages and limitations; however, a comprehensive understanding of usage requires a synthesis of both dimensions. Therefore, appropriate usage is viewed in this study as a multidimensional construct consisting of both breadth and depth dimensions, which are captured as IT acceptance (number of people making appropriate use of IT) and infusion (extent to which the IT is used appropriately) respectively.

Goal Incongruence/Behavioral Intention

TPB holds that an individual's extent of IT usage is determined by his/her intention regarding the intended behavior (see Figure 3.2). Behavioral intention in TPB is the inverse of the goal incongruence construct in PAM. This is so because the management's goal in PAM is to have all organizational users make appropriate utilization of IT, and hence, goal incongruence refers to lack of intention on the part of users to utilize IT appropriately. Goal incongruence therefore provides a link between PAM and extant models of IT usage.

The notion of goal incongruence between principal and agents regarding the intended behavior is central to the proposed IT usage model, and to agency theory in general (Sappington 1991), which may lead organizational users to shirk from appropriate IT utilization. PAM holds that goal incongruence is an inherent characteristic of most organizations, caused by the disutility gained by users from IT utilization (since it requires effort from their part) and utility gained by management from such utilization (since it furthers organizational goals). Support for this position comes from political conflict theory, which views organizations as a nexus of stakeholders with diverse and conflicting interests, often indulging in subversive political actions to gain organizational power (Pettigrew 1972, Pfeffer and Salancik 1974, Pfeffer 1981). Empirical research based on this stream has found this characterization of organizational members to be reasonably accurate (Keen 1981, Markus 1983). For example, examining the usage patterns of multimedia communication technologies at Wang Laboratories, Francik, Rudman, Cooper, and Levine (1991) observed that individual users tend to focus more on personal goals than on management or group goals; hence the goal incongruence.

However, not all users exhibit the same level of resistance toward appropriate IT utilization. Some users may derive intrinsic utility from IT utilization in form of enjoyment or improved social position among peers (Davis, Bagozzi, and Warshaw 1992). This utility may partially offset their goal incongruence regarding IT usage, which in turn, would motivate them to utilize IT appropriately. Users' degree of goal incongruence is therefore expected to be negatively related to appropriate IT usage. Note that this association is analogous to the positive relationship between behavioral intention (inverse of goal incongruence) and IT usage in TPB. In keeping with the prior IT usage literature, goal incongruence will henceforth be defined in terms of behavioral intention.

Attitude

TPB holds that individual intention regarding a behavior is predicted jointly by three determinants: attitudes, subjective norm, and perceived behavioral control (see Figure 3.2). Of these variables, attitude is considered to be the most important in the context of IT usage since it explains the most variance (about 30 percent) in behavioral intention (Davis, Bagozzi, and Warshaw 1989, Mathieson 1991). Attitude in TPB refers to a favorable or unfavorable disposition held by potential users toward appropriate IT utilization (Davis, Bagozzi, and Warshaw 1989). Despite not being a PAM construct, attitude is included in the proposed intraorganizational IT usage model by virtue of its centrality to the TPB framework as a significant predictor of behavioral intention and IT usage.

Subjective Norm

Of greater relevance to the intraorganizational usage context, is the potential role played by subjective norm in affecting intention and usage. Subjective norm refer to individual perceptions about referent others' opinions regarding the intended behavior. In the intraorganizational IT usage context, organizational users can view managers as an important referent, since management's encouragement, directives, and/or actions can significantly influence their IT usage behavior (Leonard-Barton and Deschamps 1988). Managerial influence is therefore an important determinant of the subjective norm construct in TRA and TPB (Taylor and Todd 1995), and thereby of IT usage.

Unlike attitudes, the specific set of normative beliefs contributing to subjective norm has not been formalized in the IT implementation/diffusion literature. Measures of subjective norm may therefore have been inaccurate, which may partially explain why prior TPB/TAM-based studies have failed to detect the effect of subjective norm on behavioral intention (e.g., Davis, Bagozzi, and Warshaw 1989, Mathieson 1991). PAM postulates managerial incentives and control as important normative beliefs in the context of intraorganizational IT usage, which are described later in this section. As seen in Chapter V, addition of these belief sets may help capture unique variance in behavioral intention not explained by TPB.

Usefulness and Ease of Use

TAM maintains that two sets of behavioral beliefs, namely usefulness and ease of use (as perceived by potential users), are of particular relevance in explaining individual attitudes concerning IT usage. Usefulness is defined as prospective users' subjective evaluation of whether the IT will increase his/her job performance, while ease of use refers to the degree to which users expect the target IT to be free of effort (Davis, Bagozzi, and Warshaw 1989). Note that ease of use is indirectly included in PAM since agents take the required effort into consideration while deciding on a particular behavior. Furthermore, perceived usefulness and ease of use of IT is private information to the user, and constitutes part of the state of nature that influence user behavior. Though not formally stated as PAM constructs, these behavioral beliefs can therefore be viewed and analyzed from a PAM perspective.

Risk Aversion

A third determinant of attitude, included in PAM but not in TAM, is the user's risk aversion toward the intended behavior[1] (Nilakant and Rao 1994). Risk aversion on the

[1] Users' risk aversion stem in part from their inability to diversify their employment across multiple employers (Nilakant and Rao 1994). In contrast, organizational managers can distribute their risks across multiple users and/or projects, and are therefore less risk averse (more risk neutral).

part of users may constrain their behavior under risky situations such as intraorganizational IT usage, where the behavioral outcomes are uncertain and not completely within the users' control. Users may also vary in their extent of risk aversion, which would have a corresponding differential impact on their behavior. More risk-averse users are generally more resistant toward using a new IT because of the uncertainty associated with such usage, and therefore, users' risk aversion is expected to have a negative association with appropriate IT usage. In our salesperson example, a less risk-averse salesperson will be more motivated to appropriately utilize the notebook computer compared to a more risk-averse salesperson.

Incentive Level

PAM holds that incentive and control variables represent important determinants of TPB's subjective norm construct. In the intraorganizational IT usage context, incentives offered by the management provide utility to the agent, and thereby help coalign the goals of users with those of managers and motivate user behavior toward an outcome deemed favorable by managers (i.e., appropriate IT usage). Higher levels of incentives leads to a greater coalignment of goals and increased user motivation to appropriate IT utilization. For example, if two salespeople are given unequal monetary (e.g., pay raise) or non-monetary (e.g., social recognition) rewards for correctly utilizing notebook computers in their daily sales activities, the person receiving greater rewards will be more motivated to utilize the computer. As shown in Figure 3.3, incentive level influences behavioral intention and IT usage indirectly via the subjective norm construct.

Incentive Type

Incentives can also be categorized based on their types: outcome-based (e.g., commissions based on sales) versus behavior-based (e.g., hourly wage) (Nilakant and Rao 1994); both of which are hypothesized to affect IT usage via the subjective norm construct. PAM holds that outcome-based incentives are more effective in curbing opportunistic behavior on the part of users, because they hold users accountable for the realized outcomes. By shifting part of the risks of IT usage from management to users, such incentives ensure the commitment of users to appropriate IT utilization. Behavior-based contracts, on the other hand, insure users from potential unfavorable outcomes due to inappropriate use or non-use of IT and may therefore induce them to shirk from the intended behavior. In the previous example, if a salesperson's compensation is tied to successful completion of assigned tasks and if appropriate utilization of the notebook computer is key to efficient and effective completion of these tasks, the salesperson will be motivated to utilize the computer appropriately so that the assigned tasks are performed correctly. In contrast, if he/she is paid by the hour for computer utilization, he/she may lose nothing by spending less effort on the intended behavior.

Monitoring

As noted earlier, behavior-based incentives are difficult to implement because actual user behavior (extent of appropriate IT utilization) cannot be observed or inferred by management. This introduces information asymmetry in the principal-agent relationship. Opportunistic users may take advantage of this asymmetry by putting in less effort on IT utilization than that expected by management, leading to the moral hazard problem (Arrow 1985). PAM posits under such circumstances, managers can employ control structures such as monitors to reduce opportunistic behavior by users. Though monitors may not provide accurate information about user behavior (e.g., a console log may indicate how much time an user is logged on to a computer system or how many times he/she has accessed a particular database, but will not indicate the extent to which the user has appropriately utilized the system), they are perceived by users as revealing their behavior to the users, which motivates them not to shirk from the expected behavior. For example, if the salesperson in our example is aware that his/her usage of the notebook computer is being continuously monitored, he/she would tend to utilize it more appropriately than if such monitoring were not available.

Note that control structures, such as monitoring, relative behavioral evaluation, and repeated contracts (discussed next), are relevant only in the case of behavior-based incentives. Controls are not required for outcome-based incentives, because such incentives, by their very nature, ensure user commitment by making them accountable for the realized outcomes. Though information asymmetries may exist for both incentive types, they lead to opportunistic behavior on the part of users only when behavior-based incentives are employed, and control structures may be required to remedy such opportunism. Hence, as shown in Figures 3.3, control variables do not have a direct effect on subjective norm, but rather mediate the effect of behavior-based incentives on this variable.

Behavioral Evaluation Type

A second source of information asymmetry in PAM is the management's ignorance of the state of nature as perceived by users, potentially leading to the adverse selection problem (Arrow 1985). Strictly speaking, managers will never be aware of any private information possessed by users that affect their IT utilization (e.g., their peer's perception of IT utilization) unless users volunteer this information. However, if this information is available to all users and is utilized in their rational choice of behavior, evaluating a user's behavior relative to his/her peers may help control for the state of nature common to all users, although such information is unavailable to management. In our example, if all salespeople in the company are provided with notebook computers for managing their sales activities and compensation of each salesperson is based on his/her appropriateness of computer usage relative to that of his/her peers, each salesperson would be more motivated to utilize the computer appropriately.

Relative-behavior based incentives may take several forms. One such form is a simple "tournament," where users are rewarded based on an ordinal ranking of their behavior (Sappington 1991). A promotion can be viewed as a tournament, where a single user, from within a group of users, is awarded a large prize based on his/her behavior relative to that of his/her peers. Relative behavioral evaluation in a tournament scenario may even motivate users to utilize IT more than that is required for an assigned task, in order to outperform his/her peers and receive the largest reward (Sappington 1991). Tournaments can therefore be particularly valuable incentive devices for management because it reduces opportunistic behavior on the part of users without imposing significant costs to management. However, a tournament is effective only when there is no collusion or strategic cooperation among users.

Repeated Contracts

Repeated contracts provide additional opportunities for designing incentives in cases where users' behavior and/or private information cannot be assessed accurately by management. A repeated contract setting is similar to a multiple-user setting in that, in the former, a user's behavior in one period is compared to his/her own behavior in other periods, while in the latter, his/her behavior is compared with that of other users in the same period. In the previous example, if a salesperson is provided with an annual contract whose renewal is contingent on appropriate computer utilization, he/she will be motivated to utilize it appropriately in order to improve the chances of contract renegotiation at the end of the year. Also, as the manager and user engage in a multi-period, long-term relationship, the manager may learn more about the user and be able to assess his/her behavior more accurately.

One potential problem in a multi-period principal-agent relationship is *ratchet effect*, which refers to limited effort by agents to perform up to their potential in the initial period because superior performance may be used by the principal to set higher performance standards in subsequent periods, i.e., "ratchet up" future targets (Freixas, Gusnerie, and Tirole 1985). In the above example, excellent computer utilization on the part of a salesperson will inform management of the user's superior skills, and management will expect similar levels of computer utilization from the salesperson in all subsequent periods.

However, the ratchet effect is alleviated to some extent if the technological environment varies randomly with time, i.e., when current conditions are not good indicators of future conditions (Sappington 1991). This effect is therefore not of significant concern in IT environments that change continually with time (e.g., newer and better products are developed and implemented).

3.4 Support for the Proposed Model

Kaplan (1964) notes that "a theory can be confirmed by fitting it into other theories, just as much as by fitting it to the facts." Kaplan goes on to explain two important philosophical conceptions in theory validation: (1) norms of coherence, referring to validating a theory based on its ability to relate to existing and accepted theories, and (2) norms of correspondence, where a theory is validated if predictions based on the theory are supported by empirical data. The previous section provided theoretical support for the proposed model by illustrating the "fit" between PAM and other relevant IT usage models such as TAM and TPB. This section provides empirical support by examining how well predictions based on PAM match with prior evidence on the effect of managerial incentives and control on organizational members' IT usage behavior.

Though the effects of behavioral beliefs and attitudes on users' behavioral intention and usage behavior are well established in the IT implementation literature (e.g., Davis, Bagozzi, and Warshaw 1989, Mathieson 1991, Taylor and Todd 1995), the subjective norm component and its determinants have received little rigorous attention in the literature. PAM proposed incentives and control structures as important predictors of subjective norm, and thereby indirectly affecting intention and behavior. Empirical examination of the effects of incentives on employee behavior and the relative efficacy of different forms of incentives is beginning to gain interest in the marketing and management literatures (e.g., Eisenhardt 1985, Baker, Jensen, and Murphy 1988). However, such studies are lacking in the MIS literature. Most agency theoretic studies in MIS are limited to the theoretical exposition of propositions rather than empirical testing of these propositions (e.g., Gurbaxani and Kemerer 1990). The few empirical studies in this area are mostly anecdotal in nature and lack careful research design or experimental rigor. Some of these studies are described next.

Following a survey of 422 business school faculty members, Howard and Mendelow (1991) reported that availability of incentives was one of seven factors that discriminated among zero, minimal, and high levels of computer usage. Currid (1995) observed that innovative incentives such as yielding control over employee's working agenda, providing public recognition of deserving individuals, and changing of titles can encourage higher performance levels from network staff over the long run than salary raises or bonuses. Davis, Bagozzi, and Warshaw (1992) found that enjoyment, an intrinsic incentive, can significantly influence computer usage in the workplace. These findings indicate that managerial incentives, both monetary and non-monetary, can have significant effects on organizational members' utilization of IT.

Computer-based and supervisor monitoring of employee behavior were examined by Irving, Higgins, and Safayeni (1986) and Aiello (1993) in field and laboratory settings respectively. Their results indicate that perceptions of monitoring can improve both quantity and quality of IT usage, though unfavorable side-effects such as increased stress, decreased satisfaction, and decline in the quality of relationships with peers and supervisors may also be produced. However, the effects of other types of managerial incentives and control (i.e., outcome-based incentives, relative behavioral evaluation, repeated contracts) on intraorganizational IT usage still remains to be investigated.

The apparent lack of attention of research in this area can be attributed to at least two reasons. First, difficulties in obtaining and/or controlling for appropriate incentive and control mechanisms, especially in field settings, may have discouraged empirical work in this area (Eisenhardt 1989). A few studies in the management literature have utilized financial incentives for subjects (e.g., Eisenhardt 1985), but it is unclear whether manipulation of such incentives is adequate (Eisenhardt 1989). Second, operationalization and measurement of economic constructs such as risk aversion and information asymmetry has proven difficult. The role of incentives and control mechanisms in motivating intraorganizational IT usage therefore remains one of the less-examined but potentially useful areas of IT implementation research.

3.5 PAM Assumptions and Implications for Generalizability

The principal-agent model of intraorganizational IT usage makes several behavioral assumptions about humans and organizations, that are listed in Table 3.1. The generalizability of PAM to different organizational environments will be governed by the extent to which these assumptions are generalizable. This section revisits the PAM assumptions and examines their generalizability in the context of intraorganizational IT usage.

Goal incongruence. The central premise in PAM is that the goals of principals and agents are not necessarily congruent, and that incentives can help reduce goal incongruence and motivate agents to behave in the principal's best interests. Since IT is often acquired by organizations at considerable cost, management would want organizational members to appropriately utilize the IT provided for their use, with the expectation that such usage will lead to organizational benefits. However, users value personal goals (e.g., career advancement, leisure) over group and/or management goals and may therefore have different intentions regarding IT usage, hence the goal incongruence. Such incongruence is typical of market-based and/or bureaucratic organizations (e.g., most public and private sector firms in the US), but may exist to a lesser extent in clan-based organizations (e.g., small family-owned businesses and some Japanese firms), where control is achieved via relatively complete socialization processes that reduce goal incongruence between organizational actors (Ouchi 1979). Organizational form and culture should therefore be taken into consideration when generalizing PAM to different business environments or cultures.

Self-interested behavior. This assumption holds that organizational members will act in their own best interests, even if such actions are against the interests of their employers. This assumption is supported in theory by the political conflict stream of MIS research (e.g., Kling and Iacono 1984), and by empirical case studies by Markus (1983) and Francik, Rudman, Cooper, and Levine (1991). However, organizational members may sometimes indulge in altruistic behavior (e.g., environmental awareness programs, community service), where such individualistic characterization of human beings may not hold. PAM will have limited generalizability to such contexts.

Bounded rationality. Rationality, a concept underlying much of traditional and neoclassical economics, implies that human beings make optimal decisions based on a complete assessment of all possible alternative choices and consequences (March and Simon 1993). Information regarding possible alternatives is assumed to be available readily and costlessly. However, many contemporary social scientists observe that this model of human behavior cannot be realized in an uncertain world characterized by incomplete and costly information. Rather than focusing on a perfectly rational "economic man" making optimal decisions, it is therefore suggested that research efforts be directed at a boundedly rational "administrative man" (i.e., a person whose rationality is constrained by the availability of information and his/her cognitive ability to process such information) making satisficing decisions (March and Simon 1993). PAM assumes an administrative rather than an economic man, where information asymmetry is attributed to the lack of complete and costless information about agent behavior.

Since the classic works of Von Neumann and Morgenstern (1944), research on behavioral choice under risk and uncertainty has been dominated by the notion of expected utility. Expected utility is based on three fundamental axioms (Camerer 1995): (1) *Ordering:* Preferences are complete (represented by a set of indifference curves; i.e., given two risky alternatives A and B, individuals will either prefer A over B, or B over A, or are indifferent between the two) and transitive (indifference curves do not intersect; i.e., given three alternatives A, B, and C, if A is preferred to B, and B to C, then A is always preferred to C); (2) *Continuity:* There are no empty spaces between indifference curves (i.e., if A is preferred to B and B to C, then there exists a probability p such that individuals are indifferent between outcome B and a weighted combination of A and C with weights p and 1-p); and (3) *Independence:* Indifference curves are parallel lines (i.e., if A is preferred to B, then a combination of A and a third alternative C with probabilities p and 1-p respectively will be preferred to a combination of B and C with the same probabilities).

Recent works in behavioral decision theory and experimental economics present empirical evidence that partially violates some of these axioms, as demonstrated in the Allais Paradox and the Ellsberg Paradox (for a review, see Kagel and Roth 1995). For instance, Kahneman and Tversky (1979) found that subjects overestimate very low probabilities and underestimate very high probabilities. Such deviations from rationality (called "preference reversals") have prompted alternative modes of theorizing individual choice such as prospect theory (Kahneman and Tversky 1979). The bounded rationality assumption has been an issue of intense debate among psychologists and economists for the last five decades, and the usefulness of most economic theories such as agency theory depends on the overall validity of this assumption.

Information asymmetry. Information asymmetry refers to the management's ignorance of users' actual behavior and/or perceptual beliefs influencing their extent of usage, which may subsequently lead to the problems of moral hazard and adverse selection. PAM posits that under such circumstances, control mechanisms such as monitors (e.g., supervisors and computer logs), relative performance evaluation (e.g., promotion) and repeated contracts (e.g., short-term renewable contracts) may help management reduce user opportunism and motivate their behavior (Eisenhardt 1985). The ideas of information asymmetry are generally true in the context of intraorganizational IT usage, where lack of information regarding users' behavior has been cited as one of the common reasons underlying the "productivity paradox" stream of research (Brynjolfsson 1993). However, lack of measures for assessing information asymmetry within organizations is a severe limitation to the empirical examination of this assumption.

Production efficiency. PAM assumes that the quality of effort expended by agents is always acceptable. Therefore, it focuses on the quantity of effort, with the assumption that more effort will lead to better outcomes. Although managers cannot directly relate IT usage to organizational outcomes (e.g., decision effectiveness), it is generally believed that appropriate IT utilization is necessary (although not sufficient) in order to realize the expected outcomes. However, the efficiency assumption may be overly simplistic and restrictive in the context of IT usage because effective users of IT can spend less effort using a particular IT compared to others and yet achieve better results. In other words, IT usage quantity and quality are both important for achieving organizational outcomes. As explained in Chapter IV, the current study defines intraorganizational IT usage in terms of both IT usage quantity (acceptance) and quality (infusion), in an effort to overcome this limitation. This characterization of IT usage also serves to link the dependent variables in IT diffusion and implementation streams of MIS research.

3.6 Summary

The purpose of this chapter was to develop a theory-based model to explain how managerial incentives and control can influence IT usage behavior within organizations. Toward that end, principal-agent research from the microeconomics literature was employed to first model the management-employee relationship regarding intraorganizational IT usage and then, incorporate principal-agent ideas within a theory of planned behavior (TPB) framework, to develop a principal-agent model of IT usage (Figure 3.3).

PAM explains how managers can employ different forms of incentives to motivate users to utilize IT provided to them, and suggests factors (e.g., goal incongruence) that mediate the effect of such incentives on IT usage. It also indicates potential conflicts (e.g., moral hazard and adverse selection) that may arise due to information asymmetry in the manager-user relationship, and shows how control mechanisms (e.g., monitoring, relative behavioral evaluation and repeated contracts) can help remedy such conflicts.

Based on the implications of this theory, a research model of intraorganizational IT usage is developed for subsequent empirical testing. This model provides theoretical relationships between PAM constructs (goal incongruence, risk aversion, incentive level, incentive type, monitoring, behavioral evaluation type, and repeated contracts) and TAM constructs (behavioral intention, attitude, ease of use, and usefulness) within a TPB framework (behavior, intention, attitudes, and subjective norm) to provide a more comprehensive understanding of intraorganizational IT usage, than that accorded by prior models. Support for the proposed model is derived by examining its fit with prior empirical findings regarding the effects of incentives and control on IT usage. The reasonableness of organizational and human assumptions of PAM (i.e., goal incongruence, self-interested behavior, information asymmetry, bounded rationality, and production efficiency) are critically examined in order to assess the generalizability of the proposed model to different organizational environments.

PAM shares several similarities with TAM. These similarities are not surprising, given that both PAM and TAM are fundamentally models of IT usage, albeit in different contexts. The dependent variable in both models is IT usage. Beliefs about required effort in PAM is similar to the inverse of ease of use construct in TAM, while the state of nature may consist of usefulness as well as other belief sets (e.g., enjoyment) affecting IT usage. The agent's decision problem in PAM (see Figure 3.1) is essentially the same as TAM, if external influences, such as managerial incentives and control, are not taken into consideration. In other words, PAM can be viewed as an extension of TAM to the organizational context and an application of TPB to the intraorganizational IT usage context.

TAM is reported to explain only about 30 percent of the variance in IT usage (Taylor and Todd 1995). PAM suggests how TAM should be modified in order to accommodate managerial incentives and control in organizational settings, and is thereby expected to explain a greater proportion of the variance in the dependent variable. In doing so, PAM provides the much needed linkage between micro-level individual variables and macro-level managerial variables that has been urged in the IT implementation/diffusion literature (DeSanctis 1984). The epistemological contribution of PAM to IT implementation/diffusion research is in theorizing the linkage between managerial influences (incentives and control) and organizational members' use of IT.

By addressing the role of managerial influences (incentives and control) on organizational members' IT usage behavior, the model proposed in this chapter becomes more relevant to managers interested in rapid and effective implementation/diffusion of IT within their organizations. However, the potential usefulness of this model in understanding and/or predicting intraorganizational IT usage however remains unexplored because of the paucity of empirical studies in this area. Subsequent chapters of this dissertation undertake such an effort.

Chapter IV

RESEARCH PLAN AND METHODOLOGY

The principal-agent model of intraorganizational IT usage presented in Chapter III was empirically tested using a laboratory experiment. This chapter discusses methodological issues related to this laboratory study, and is organized into five sections. The first section describes the research approach employed and the rationale for selecting such an approach. This is followed by a description of the research setting, subjects, task, and treatments used in the experiment. The experimental design and controls for threats to internal and external validity accommodated by this design are presented in the third section. The fourth section describes operationalization and measurement of model variables and assumptions. The chapter ends with a summary of the preceding sections.

4.1 Research Strategy

A laboratory experiment was used to test the research model proposed in Chapter III. This section presents a background of the laboratory approach, and is organized in three parts. The first part presents the structure, strengths, and weaknesses of laboratory experiments in general. This is followed by a discussion of the fundamental tradeoff between internal and external validity in scientific inquiry in an effort to justify the selection of a laboratory experiment for this study. The section ends with an outline of the long-run research strategy that will be employed subsequent to this dissertation.

4.1.1 Structure of Laboratory Experiments

Experimentation is defined by philosophers of science as a form of controlled scientific investigation (Nagel 1961). This approach has a long and distinguished history, dating back to the classic works of Aristotle around 340 BC, which attempted to trace the development of embryo from newly laid eggs to hatching of the chicken (cf. Mason 1989). The logical structure underlying the experimental approach is depicted in Figure 4.1. An experiment is designed to understand events occurring in the real world, and in addition, to contribute to a body of theories that attempt to explain or predict the real world phenomenon. In this approach, a natural process is isolated from the real world and studied systematically in an artificial or contrived setting to logically deduce a set of relationships, that are then extended to the real world phenomenon.

In the traditional hypothetical-deductive approach of experimental research (Kaplan 1964), existing theories are used to select two or more conceptual variables of interest to the researcher. One or more of these variables, called independent or treatment variables, are artificially manipulated or controlled by the researcher, while others, called dependent or response variables, are observed and recorded as an outcome of the experimental process. Relationships among these variables are postulated in form of hypotheses, that are empirically tested, typically using statistical tools, to derive inferences about the real world phenomenon.

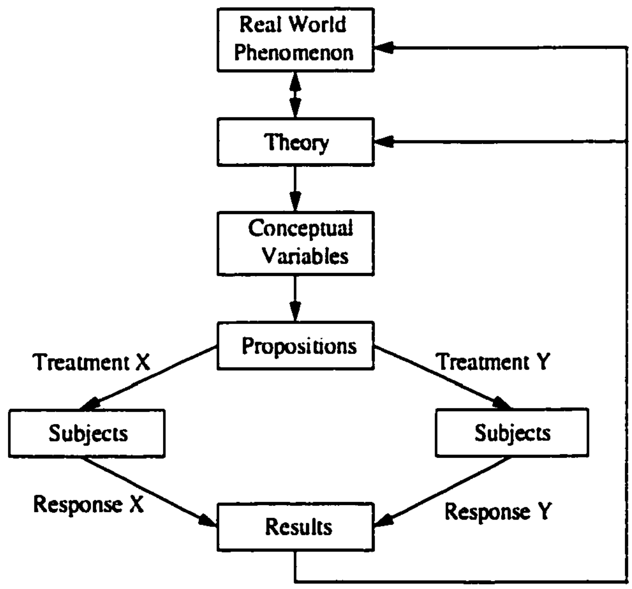

Figure 4.1 The logical structure of an experiment (modified from Mason 1989)

The purpose of any scientific inquiry is to produce new knowledge. Ideally, this knowledge should satisfy two criteria: (1) *internal validity:* the results should support causality between independent and dependent variables, and (2) *external validity:* the results should be generalizable to the real world. Internal validity asks the question, "was a change in a response variable caused by corresponding changes in treatment variables," while external validity asks, "to what extent can the findings of the study be generalized to other tasks, subjects, and settings" (Huck, Cormier, and Bounds 1974).

The notion of internal validity or causality has dominated much of the progress in the development of the experimental approach (Mason 1989). Administration of a treatment T and measurement of response R does not logically imply that "T caused R" (Mason 1989). For instance, the observed changes in response variables may have been caused by extraneous variables outside the scope of the study or by the experimental process itself, thereby confounding the hypothesized relationships. Controls are required to overcome the threat of such confounding associations and ascertain with a reasonable degree of confidence, that observed variations in response variables were in fact caused by corresponding changes in the treatment variables. The strength of a laboratory experiment lies in its ability to systematically impose a variety of manipulative and statistical controls that can isolate the influences of extraneous mediating variables and/or alternative hypotheses, thereby justifying a cause-effect relationship between independent and dependent variables. Consequently, a high level of internal validity can be expected from a properly designed laboratory experiment.

On the other hand, laboratory experiments has been criticized for lack of external validity or generalizability in their findings. Because these experiments are conducted in laboratory setting isolated from real-life, it is difficult to assess whether the results reflect reality. Critics contend that laboratory experimentation, at best, provides rough and approximate models of real-life phenomena, can examine only a few research variables, and can potentially lead to erroneous conclusions because of unsuspected real-life interactions that were ignored in the experimental setting (Chapanis 1983). Chapanis further argues that laboratory experiments seldom deal adequately with boundary conditions and contextual factors and may therefore lend themselves to unjustified and often inaccurate extrapolations.

Field experiments are sometimes suggested to remedy the problem of external validity in laboratory experiments. Field experiments involve manipulation of independent variables in one or more actual organizations, and hence the results are expected to be more realistic. However, the success rate of such experiments is minimal, primarily due to violation of controls in favor of operational considerations in the organizations where these studies are conducted (Jenkins 1985). Empirical evidence also indicates that field study results are not inherently more generalizable than that of laboratory experiments, especially when generalizing across actors, behaviors, and settings (Benbasat 1989).

4.1.2 Tradeoff between Internal and External Validity

Social science researchers have noted that all scientific research is subject to a fundamental tradeoff between internal validity (achieved via tightness of control) and external validity (obtained via worldly realism), and that one can be achieved only at the cost of the other (Huck, Cormier, and Bounds 1974, Mason 1989). This tradeoff is illustrated in Figure 4.2 in form of isoepisteme curves (i.e., curves joining points of equal, partial knowledge). Different knowledge states between zero knowledge (zero on both realism and control dimensions) and ideal knowledge (high on both dimensions) can be represented by a set of isoepisteme curves, a concept similar to indifference curves in microeconomic theory. Different points along the same curve are characterized by different levels of realism and control, while yielding the same knowledge level. For example, though points A and B in Figure 4.2 yield the same level of knowledge; knowledge at A has greater control while knowledge at B possess greater realism.

Realism and control are determined, to a significant extent, by the research approach employed in a study. As indicated by the asymptotic nature of the isoepisteme curves, no methodology is completely devoid of either control or realism. While laboratory experiments generally tend to cluster around point A in Figure 4.2, moving towards point B in approximate order are field experiments, field surveys, and case research (Mason 1989). However, the amount of knowledge generated in a research project depends not on the levels of realism and control desired, but on the skill and care with which the research is conducted. For example, a well-executed case study may possess more realism and greater control than a poorly conducted laboratory experiment (thereby placing the research on a higher isoepisteme curve) and vice versa. The knowledge yield of any research methodology can be improved by incorporating reasonable assumptions, better research designs, and careful operationalization of variables.

The amount of knowledge gained from any research activity is, however, delimited by the availability of resources. Irrespective of the methodology employed, greater control or realism typically require additional resources such as money, time, instrumentation, and availability of subjects, that can only be achieved at a cost (Mason 1989). This resource constraint is indicated on Figure 4.2 by a negatively-sloping straight line. Economic theory suggests that a research project will provide the most knowledge for the dollar if it lies at a point where the resource constraint line is tangential to the highest isoepisteme curve.

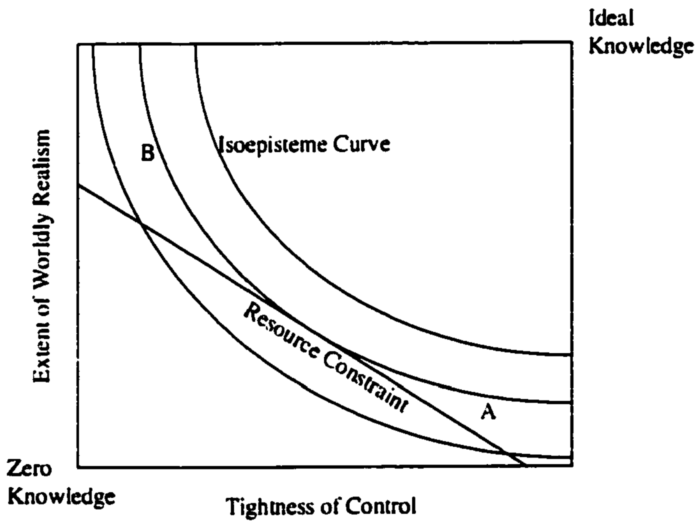

Figure 4.2 Trade-off between control and realism in empirical research (adapted from Mason 1989)

Social sciences researchers are often faced with the dilemma of choosing between control (internal validity) and realism (external validity) while selecting a research approach appropriate for the object of inquiry. While some believe that nomothetic approaches such as laboratory experiments, by virtue of their better controls, are inherently more "scientific" than qualitative approaches (e.g., Bateman and Ferris 1984), others contend that idiographic approaches such as case studies offer greater insights into the object of inquiry because of their extensive analysis of the context and actors' behaviors (e.g., Mintzberg 1984). Such conflict has been at the heart of an extensive debate between positivistic and anti-positivistic science for over the last two centuries (Hirschheim 1985). Rather than choosing one over the other, research efforts should seek reasonable levels of control and realism within given resource constraints. As argued by Fromkin and Streufert (1983), "without internal validity, an experiment is necessarily doomed to failure; without external validity, it is of little use to those who would apply the research."

4.1.3 Research Plan

Since control can only be achieved at the cost of realism and vice versa, a combination of research approaches, characterized by different levels of control and realism, may help overcome limitations associated with either approach. Mason (1989) referred to such combination of approaches as "research programs," and argued that the knowledge generated from such programs would lie on higher isoepisteme curves than that from any single approach. For instance, if a laboratory experiment establishes point A in Figure 4.2 and a field survey of the same phenomenon establishes point B, drawing inferences simultaneously from both approaches will place the combined result along a straight line joining A and B. By virtue of the convexity of isoepisteme curves, this point will always be at a higher knowledge level than either A or B. Furthermore, combination of approaches enable "methodological triangulation" (Subramanian and Nilakanta 1994); they serve to corroborate the strength of derived inferences.

This current study can be described as the beginning of a cumulative research program examining the effect of managerial incentives and control on intraorganizational IT usage. The first step in this program is to establish internal validity for the proposed associations by means of a laboratory experiment. In the long run (subsequent to this dissertation), with the availability of sufficient time and resources, this experiment may be followed by a field survey of IT users in two or three organizations employing different forms of incentives and control mechanisms related to IT usage, in an effort to extend the external validity of the laboratory findings to real-life settings.

The selection of laboratory experiment and field survey was motivated by the complementary nature of these approaches. While it is difficult to derive causal inferences in field surveys because of the retrospective nature of data collected (i.e., time ordering between the independent and dependent variables cannot be ascertained because all variables are measured at the same time) and lack of experimental control (i.e., independent variables can be measured but not manipulated), this problem is alleviated in a laboratory setting by employing appropriate controls and measuring independent variables prior to the experimental treatment. On the other hand, laboratory studies suffer from limited worldly realism because of the artificial environment in which they are contrived. This threat to external validity is reduced in field surveys by collecting data from subjects in actual organizations. A combination of the two approaches is therefore expected to produce results that are both reliable and generalizable, and thereby contribute to an better and more comprehensive understanding of intraorganizational IT usage.

4.2 Research Setting

This section describes methodological issues related to the current laboratory experiment, including subjects, task, and treatments. Students from a sophomore-level computer applications class at a large southwestern university served as subjects for this laboratory study. Subjects received bonus points toward their class grade for participating in a business task that involved the potential use of a new software tool. Subject participation was voluntary, and willing subjects were asked to sign up for a two-hour session at the college's computer laboratory[1] on one of several available dates. The two-hour duration of the experiment was based on an initial pilot study described in Chapter V. Prior to the experimental treatment, subjects were introduced to similar tasks and IT via an in-class demonstration, and were shown how to complete such tasks using the intended IT as well as using other IT and non-IT means. Subjects were provided with written tutorials so that they could practice using the IT prior to the actual treatment. They were also asked to bring a hand calculator for the experimental session, should they decide to use it for calculation or other purposes.

On the scheduled date and time, subjects were asked to select any one of the twenty computers in the laboratory (treatments were randomly preassigned to each machine, based on the output of a random number generator program). They were asked to sign a consent form indicating their approval of participation in the research project and to complete a pre-treatment questionnaire intended to elicit their perceptions of the treatment

[1] This computer laboratory was equipped with twenty microcomputers (Intel 486 processors, 25 MHz clock speed) on a Novell local area network, which was typical of what students used for this class.

variables. Subjects were then given the experimental task and asked to complete it using any IT or non-IT of their choice. If they used a computer, subjects were asked to save their work on diskettes so that it could be evaluated at a later time. On completion of the task, a post-treatment questionnaire was administered to assess subjects' perceptions of the response variables and model assumptions. The pre-treatment and post-treatment questionnaires are provided in Appendix A and discussed in detail in Section 4.4.

The task selected for this study involved a managerial budget allocation problem that could be facilitated by the use of IT. In this task, subjects assumed the role of a marketing manager of an appliance store, and were asked to determine the exact number of refrigerators, stoves, and microwave ovens to purchase, subject to budgetary, warehouse, and back order constraints, in order to take advantage of promotional dealer pricing for selected models of these products. This task is fairly typical of tasks faced by marketing managers in organizational settings (McIntyre 1982), and has been employed in slightly different forms on several instances in prior MIS research, e.g., while investigating the effects of graphical/tabular and color/monochrome displays on decision performance (Benbasat, Dexter, and Todd 1986) and examining the effects of prior user expectations on decision performance and satisfaction (Szajna and Scamell 1993). The reasonableness of this task for the subject sample was verified using an initial pilot study (described in Chapter V). To eliminate effects of task novelty, subjects were provided with a written tutorial of a similar task prior to the actual treatment. The experimental and tutorial tasks are provided in Appendix B.

Microsoft Excel's SOLVER, a tool for solving linear programming and integer programming problems, was the IT recommended for performing the assigned task. Subjects were told that SOLVER was particularly suited for complex tasks of this type and that it enhanced user productivity by decreasing the time expended and reducing potential errors in performing such tasks. However, subjects were free to use any other IT or non-IT of their choice for completing the task (e.g., by employing a hand calculator or using trial-and-error techniques in Excel). This degree of freedom was necessary to ensure that subjects' use of IT was voluntary. Different ways of performing the task were demonstrated prior to the treatment, so that subjects were aware of possible alternatives.

Though Excel was taught as part of the computer applications class, SOLVER was not part of the curriculum and was hence not covered in class. Two pilot studies, reported in Chapter V, revealed that over 98 percent of the students in this class did not have any prior exposure to this tool, and therefore, its use was reasonable for examining subjects' usage of new IT. The human subjects protection committee at the university required that only software tools related to the class curriculum be employed for examining the behavior of student subjects, and hence, use of software packages not part of the class curriculum was ruled out.

4.3 Experimental Design

An experimental design is intended to serve two purposes: (1) to help answer a research question, and (2) to control for possible rival hypotheses and extraneous variables that may confound the observed effects on the dependent variable (Huck, Cormier, and Bounds 1974). The quality of the experimental design determines the degree to which a researcher can control for issues such as random assignment of subjects, manipulation of independent variables, and internal and external validity of inferences.

The research design employed in this study was an extension of a true experimental design called *multi-group posttest only design*[2] with six treatments (Huck, Cormier, and Bounds 1974, p. 274). The six treatment groups represented different combinations of the five incentive and control variables examined in this study (i.e., incentive level, incentive type, monitoring, behavioral evaluation type, repeated contracts). The six treatment groups are illustrated in Table 4.1.

R	X1	O
R	X2	O
...	...	...
R	X6	O

Legend: R: Random assignment of subjects
O: Observation of dependent variables
X1 ... X6: Treatments

Figure 4.3 Multi-group posttest only design with multiple treatments

Treatment variables were operationalized dichotomously (i.e., incentive level: low versus high, incentive type: behavior-based versus outcome-based, monitoring: present versus absent, behavior evaluation type: relative versus absolute, and repeated contracts:

[2] Though this study utilized pre-treatment and post-treatment questionnaires, the pre-treatment questionnaire only measured treatment, while the post-treatment questionnaire measured response variables. Because response variables (IT usage) could not be measured prior to the experimental treatment, this study did not qualify as a multi-group pretest-posttest design.

present versus absent) and manipulated via random assignment of subjects into six treatment groups. These treatments as well as other model variables (i.e., risk aversion, behavioral intention, subjective norm, attitude, ease of use, and usefulness) were measured perceptually using multiple-item Likert scales for purposes of statistical analysis. Operationalization and measurement issues are considered in detail in Section 4.4.

Table 4.1 Treatment group assignment

Low incentives		High incentives			
No repeat contracts	Repeated contracts	Outcome-based	Behavior-based		
			Relative behavior	Absolute behavior	
				No monitoring	Monitoring
Treatment group 0	Treatment group 1	Treatment group 2	Treatment group 3	Treatment group 4	Treatment group 5

Based on an a priori analysis of statistical power (Baroudi and Orlikowski 1989), it was determined that for a 0.05 level of significance and "medium" population effect size of 0.30[3], 22 observations were required in each cell in Table 4.1 in order to achieve acceptable statistical power of 0.80 during subsequent model testing (cf. Cohen 1988). Statistical power is given by the formula Power = $1 - \beta$, where β is the probability of a Type II error. As a rule of thumb, β is set equal to four times the significance level α (the probability of a Type I error) (Straub 1989). Since the target value of α is 0.05 for most statistical tests, β of 0.20 or statistical power of 0.80 was considered adequate.

[3] Cohen (1988) holds that 0.30 is typical of medium effect sizes (standardized difference between group means) for regression-based approaches in the behavioral sciences.

The research design employed in this study helped control for several threats to internal and external validity. Possible threats to internal validity (causality) in experimental studies include history, maturation, testing, instrumentation, statistical regression, selection, and mortality, while threats to external validity (generalizability) include population generalizability, treatment-subject interaction, multiple treatment interference, history-treatment interference, pretest-posttest sensitization, measurement-treatment interaction, Hawthorne effect, novelty effect, and Rosenthal effect (Huck, Cormier, and Bounds 1974, p. 258). Table 4.2 provides brief descriptions of these threats and explains how the current experimental design controlled for these threats.

As indicated in Table 4.2, most threats to internal and external validity, such as testing, instrumentation, and pretest-posttest sensitization, were controlled in this study by virtue of the short duration of the treatment (two hours), random assignments of subjects to treatment groups, absence of pretests or multiple treatments, isolation of the experimental setting, and multi-method measurement of the research variables. However, a few threats, such as Hawthorne effect and population generalizability, still remained because of the artificial nature of the experimental setting and the use of a convenience sample of student subjects. Such generalizability concerns are typical of most laboratory experiments in the behavioral sciences.

Table 4.2 Threats to validity and measures taken to control them

Threats to validity	*Description of threats*	*Steps taken to control for threats*
Internal validity:		
History	Possibility of other events in/out of the experimental setting potentially affecting the DV.	Short duration (two hours) of the treatment. Experiment conducted in an isolated setting.
Maturation	Biological/psychological changes in subjects occurring with time that may affect the DV.	Short duration of the treatment.
Testing	Subjects adjusting to the testing procedure.	Multi-method measurement of DV and IV. Use of a single treatment.
Instrumentation	Effect of change in observational technique on the DV.	Pilot tests to validate instrument. Multi-method measurement of DV.
Statistical regression	Effects of extreme scores from prior tests.	Absence of pretests.
Selection	Bias caused by self-selection of treatment by subjects.	Random assignment of subjects to treatment groups.
Mortality	Loss of subjects between pretests and posttests.	Short duration of the treatment.
External validity:		
Population generalizability	Subject sample cannot be generalized to the target population.	Many of the subjects work part-time in actual businesses and use IT at work. *Remains a potential threat.*
Treatment-subject interaction	Possible interaction between treatments and subject characteristics.	Random assignment of subjects to treatment groups. Using multiple subjects per treatment.
Multiple treatment interference	In a multiple-treatment study, effect of second treatment being confounded with that of the first.	Only one treatment per subject.
History-treatment interaction	Historical events during experiment interacting with the treatment effect.	Experiment conducted in an isolated setting. *Remains a potential threat.*
Pretest-posttest sensitization	Administration of pretest sensitizing subjects to the posttest.	Absence of pretests for DV. Different sets of variables measured in pre-treatment and post-treatment questionnaires.
Measurement-treatment interaction	Measurement conducted during a treatment may confound treatment effect.	No obtrusive measurement conducted during the treatment.
Hawthorne effect	Subjects' knowledge of participating in an experiment may affect their behavior.	Purpose of the study is not revealed to subjects prior to treatment. *Remains a potential threat.*
Novelty (disruption) effect	The novelty or innovative nature of treatment may affect subjects' responses	Hardware devices/settings used in the study is same as that typically used by subjects outside of the experimental setting.
Rosenthal (experimenter) effect	The experimenter may unintentionally modify subjects' behavior though non-verbal cues, etc.	Written instructions for treatment. *Remains a potential threat.*

Legend: DV denotes the dependent variable (IT usage), while IV denotes independent variables

4.4 Operationalization of Variables

Eleven model variables (i.e., behavioral intention, subjective norm, attitude, ease of use, usefulness, risk aversion, incentive level, incentive type, monitoring, behavior evaluation type, and repeated contracts) were employed in the current study, in addition to two dependent variables (IT acceptance and IT infusion) as operationalizing intraorganizational IT usage. While some of these variables (e.g., incentive level, monitoring) were taken from PAM, others (e.g., attitude, usefulness) were adopted from TAM in an effort to test the integrated IT usage model developed in Chapter III. In addition, several behavioral assumptions of the model, such as rationality, self-interest, and voluntariness, were checked for their validity. This section describes operationalization, modes of measurement, scales, and sources for these variables and assumptions.

The incentive/control variables used in this study (e.g., incentive type, behavioral evaluation type) were new to the IT implementation/diffusion context, and prior research offered very little guidance for their operationalization. Principal-agent studies in the microeconomics literature were of little help in this regard since these studies were mostly conceptual and were more concerned with theory building than theory testing (e.g., Arrow 1985, Sappington 1991). Given the lack of established guidelines, these variables were operationalized in this study in dichotomous terms (e.g., low versus high, present versus absent), and manipulated via treatment group assignment. The adequacy of all variables was however checked using subjects' perceptions elicited via the pre-treatment questionnaire (see Appendix A).

Perceptual scales for measuring model variables were either drawn from prior empirical studies in IT implementation/diffusion (e.g. Moore and Benbasat 1991, Mathieson 1991), or developed by the researcher based on the recommendations of Ajzen and Fishbein (1980). Individual items were worded in the form of statements such as "I intend using SOLVER for doing this assignment" (from the behavioral intention scale), and subjects were asked to indicate their degree of agreement to these statements on a 7-point Likert scale ranging from "strongly disagree" to "strongly agree." The use of perceptual, self-reported measures was justified, since innovation diffusion theory holds that individual behavior depends not on objective measures of variables, but rather on the individual's perceptions of these variables (Rogers 1983, Moore and Benbasat 1991). Measurement of independent (antecedent) variables prior to the treatment and the dependent (consequent) variables after the treatment preserved the time ordering among these variables, which provided for greater causal strength (internal validity) to the hypothesized relationships. Operationalization and measurement scales for these variables are listed in Table 4.3 and are discussed in subsequent paragraphs.

Intraorganizational IT Usage

The dependent variable in this study, intraorganizational IT usage, has been studied extensively in the IT implementation/diffusion literature. However, there is little consensus among researchers on how to operationalize or measure it. Table 4.4 lists various measures of IT usage employed in eighteen empirical implementation/diffusion studies. A review of these studies indicates that measures of usage have been binary, such as IT use

Table 4.3 Operationalization of research variables and assumptions

Variable	*Operationalization*	*Mode of measurement*	*Scale*	*Source*
IT acceptance	Whether SOLVER was used (and not subsequently rejected) during the task	Auditing software Three-item perceptual measure	Binary Interval	- Davis et al. (1989)
IT infusion	Number of SOLVER functionalities used in performing the task	Post-treatment examination of diskette Three-item perceptual measure Check-off list (self-reported)	Ratio Interval Ratio	- None None
Behavioral intention (goal incongruence)	Degree to which subject intends utilizing SOLVER in performing the task	Three-item perceptual measure	Interval	Mathieson (1990)
Subjective norm	Degree to which subjects believe that SOLVER usage is expected of them by the researcher	Three-item perceptual measure	Interval	Taylor and Todd (1995)
Attitude	Subjects' positive or negative disposition toward SOLVER usage	Three-item perceptual measure	Interval	Taylor and Todd (1995)
Usefulness	Degree to which SOLVER is perceived as being better than other IT/non-IT	Three-item perceptual measure	Interval	Moore and Benbasat (1991)
Ease of use	Degree to which SOLVER is perceived as being easy to use	Three-item perceptual measure	Interval	Moore and Benbasat (1991)
Risk aversion	Degree to which subject is averse to risky behavior	Four-item perceptual measure	Interval	Jackson et al. (1972)
Incentive level	Whether incentive provided to subject is high or low	Randomly assigned treatment Three-item perceptual measure	Binary Interval	- None
Incentive type	Whether incentive provided is behavior-based or outcome-based	Randomly assigned treatment Three-item perceptual measure	Binary Interval	- None
Monitoring	Whether SOLVER usage is being monitored	Randomly assigned treatment Three-item perceptual measure	Binary Interval	- None
Behavioral evaluation type	Whether incentive provided is based on subject's absolute or relative behavior	Randomly assigned treatment Three-item perceptual measure	Binary Interval	- None
Repeated contracts	Whether subject can receive more incentives subsequent to the current task	Randomly assigned treatment Three-item perceptual measure	Binary Interval	- None
Rationality	Degree to which subject is rational in his/her decision-making	Self-reported lotteries One-item perceptual measure	Binary Interval	Thaler (1987) None
Self-interest	Degree to which subject exhibits self-interested behavior	Three-item perceptual measure	Interval	None
Voluntariness	Degree to which the use of SOLVER is voluntary	Three-item perceptual measure	Interval	Moore and Benbasat (1991)

versus non-use (e.g., Alavi and Henderson 1981), as well as continuous, such as connect time (Lucas 1978, Srinivasan 1985), number of computer inquiries (King and Rodriguez 1981), and frequency of use (Ein-dor, Segev, and Steinfeld 1981, Raymond 1985, Srinivasan 1985). In addition, both objective measures utilizing hardware monitors (e.g., Lucas 1978, Ginzberg 1981a, Gremillion 1984) and self-reported perceptual measures (e.g., Fuerst and Cheney 1982, DeLone 1988, Davis, Bagozzi, and Warshaw 1989) have been employed. Finally, behavioral intention to use IT has been employed as a surrogate for actual usage (e.g., Chatterjee and Eliashberg 1990, Mathieson 1991).

As argued in previous chapters, this study considers both acceptance and infusion to be important dimensions of IT usage. While acceptance represents the breadth of usage among organizational members, infusion indicates the depth of such usage. Consistent with prior research, *acceptance* was operationalized in this study as the binary decision to appropriately utilize or not utilize an IT. Because this study involved one-time use of SOLVER, frequency or regularity of use could not be employed as an acceptance measure. However, unlike previous studies that did not rule out accidental selection of IT or its subsequent rejection, the current study considered SOLVER to be accepted if only it was used for a minimum of five minutes. The five minute threshold was determined from two pilot studies (described in Chapter V), where five minutes was the minimum amount of time spent by any subject on using SOLVER for correctly completing the budget allocation task correctly[4]. The amount of time subjects spent using SOLVER in the experimental study was recorded without the users' knowledge by a network auditing software

[4] This particular user took about fifteen minutes to complete the assignment, the remainder of the time was expended on understanding the problem and organizing it on a Excel spreadsheet.

Table 4.4 Empirical measures of IT use
(updated from Trice and Treacy 1988)

Authors	*IT/IS*	*Research methodology*	*Description of measure(s)*
Schewe (1976)	IS in general	Field survey: middle managers in firms	Monthly requests for information
Alavi and Henderson (1981)	Work force and production scheduling DSS	Lab experiment: 45 graduate students in one university	Use or non-use of computer based decision aids (O)
Ein-dor, Segev and Steinfeld (1981)	PERT scheduling tool	Field survey: 24 managers in one R&D organization	Frequency of use (P) Frequency of intended use (P)
Ginzberg (1981a)	On-line portfolio management system	Field survey: 29 portfolio managers in one US bank	Number of minutes (O) Number of sessions (O) Number of functions used (O)
King and Rodriguez (1981)	Strategic system	Lab experiment: 45 MBA students in one university	Number of queries (O) Nature of queries (O)
DeSanctis (1982)	DSS	Lab experiment: 88 senior-level students	Motivation to use (P)
Fuerst and Cheney (1982)	DSS	Field survey: 64 users in oil companies	Frequency of general use (P) Frequency of specific use (P)
Culnan (1983)	IS in general	Field survey: 362 professionals in 2 firms	Frequency of use (P)
Gremillion (1984)	Overall	Field survey: 66 units of National Forest system	Expenditures/charges for computing use (O)
Raymond (1985)	IS in general	Field survey: 464 small manufacturing firms	Frequency of use (P) Regularity of use (P)
Srinivasan (1985)	Computer-based modeling systems	Field survey: 29 firms	Frequency of use (O) Time per computing session (O) Number of reports generated (O)
Barti and Huff (1985)	DSS	Field survey: 42 decision makers in 9 firms	Percent of time DSS is used in decision making situations (P)
Baroudi, Olson, and Ives (1986)	IS in general	Field survey: 200 production managers in firms	Use of IT to support production (P)
Swanson (1987)	IS in general	Field survey: 182 users in 4 firms	Average frequency of reported information (P)
Davis, Bagozzi, and Warshaw (1989)	Word processing package use	Lab experiment: 107 MBA students	Frequency of use (P)
Chatterjee and Eliashberg (1990)	Career counseling software	Lab experiment: 65 students	Behavioral intention to use (P)
Howard and Mendelow (1991)	IS in general	Field survey: 422 business school faculty members from 62 universities	Percentage of total work time spend using computers (P)
Boynton, Zmud, and Jacobs (1994)	IS in general	Field survey: 132 firms	Use in support of: cost reduction, management, strategy planning, competitive thrust (P)

Note: O and P within parentheses denote objective and perceptual measures respectively.

package called SofTrack[5] (see Appendix C for sample SofTrack output). Acceptance was also measured perceptually using a multiple-item scale on the post-treatment questionnaire (see Appendix A). Simultaneous use of objective and perceptual measures of usage, as recommended in the IT implementation/diffusion literature (e.g., Trice and Treacy 1988), was intended to serve two purposes: (1) to generate a richer set of data that could enable data triangulation, and (2) to examine the fit between objective and perceived measures of usage, especially since one recent study (Straub, Limayem, and Karahanna-Evaristo 1995) provided evidence for the lack of such fit.

Infusion has been more problematic to operationalize and measure in the IT implementation/diffusion literature. Some studies have operationalized infusion as "extent of microcomputer adoption" (Lind, Zmud, and Fischer 1989) and "extent of database machine implementation" (Hoffer and Alexander 1989), without explaining how they were measured. Others operationalized infusion as "the portion of key tasks with computer support" (Kwon 1990). Such operationalizations capture infusion across a range of tasks and were not applicable here because the current study was concerned with measuring infusion with respect to a single task (the budget allocation problem). Infusion was therefore operationalized as the number of correct functionalities within SOLVER utilized by subjects in performing the assigned task. A checklist of SOLVER functionalities appro-

[5] SofTrack, from ON Technology Corporation, Cambridge, Massachusetts, is a tool for monitoring individual usage of microcomputer-based software on a local area network running Novell Netware. SofTrack utilizes a Netware Loadable Module (NLM) to dynamically load itself whenever the monitored software is invoked by any client machine on the network. Specific files and/or users to be monitored can be specified (in this case, solver.xla and solver.dll), and the software keeps track of all activities by the specified users on these files over the specified period of time. The usage report groups users by the files being monitored, and also displays the network node where they used these files, the time they started using these files, and the time they stopped using them.

priate for the experimental task was constructed based on guidelines provided in the Microsoft Excel users' manual. The diskettes turned in by subjects on task completion were then examined to verify which of these functionalities were used in performing the task. The various functionalities, options, values, and constraints utilized within SOLVER were recorded with the Excel file similar to a macro, that could be invoked and examined at any later time. This assessment did not take into account the use of functionalities that were not required or those that were used improperly. Infusion was also measured perceptually employing a multiple-item, Likert-scaled measure on the post-treatment questionnaire (see Appendix A). An additional check-in item was used to elicit subjects' self-reported infusion: where subjects were provided with a list of functionalities and asked to check those (as many as applicable) that were used during the task. Several spurious functionalities were included in this list to guard against possible random checking by subjects who did not appropriately SOLVER.

Individual items on perceptual scales for acceptance and infusion were culled from previously developed instruments (e.g., Mathieson 1991, Taylor and Todd 1995), and psychometrically validated in the current study using data from two pilot studies. Individual items in these scales appear in Appendix A, while the instrument validation process as well as scale reliabilities and validities are reported in Chapter V of this dissertation.

Behavioral Intention

Both PAM and TAM hold that goal congruence (inverse of behavioral intention to use IT) between management and users regarding IT utilization is the immediate predictor of intraorganizational IT usage. Since management's goal is to have all users make appropriate utilization of IT, goal congruence was operationalized in this study as the lack of subjects' intention to use SOLVER and measured perceptually prior to the experimental treatment using Mathieson's (1991) three-item behavioral intention scale (see Appendix A). This scale was based on TAM and reported to have a Cronbach alpha of 0.97 (Mathieson 1991), however its reliability was again assessed in this study using exploratory and confirmatory factor analysis, as described in Chapter V.

Subjective Norm

Subjective norm, in the IT usage context, refers to the degree to which organizational users' believe that appropriate IT utilization is expected of them by management. Prior investigations of this variable failed to detect significant effects on IT usage (e.g., Davis, Bagozzi, and Warshaw 1989, Mathieson 1991), which may be partly attributed to inaccurate measures of subjective norm that ignored the determinants of this variable. In this study, it is argued that subjective norm represents a collection of beliefs related to managerial incentives and control that affect users' behavioral intention to utilize IT and usage behavior (see Chapter III). Subjective norm was operationalized in two different ways: (1) as the traditional measure of this variable using a scale developed by Taylor and Todd (1995), which was tailored specifically to subjects' usage of SOLVER in the experimental task (see pre-treatment questionnaire in Appendix A), and (2) as a higher order construct defined in terms of two main effects and three interaction effects of incentive/control variables being examined in this study. As described in Chapter V, the Taylor and Todd scale (reported to have a reliability of 0.88) was used to assess the TPB model in its pristine form, while the higher-order scale was used to examine the increase in explanatory power in TPB accorded by PAM's incentive and control variables.

Attitude

Attitude refers to positive or negative disposition held by IT users toward the IT under consideration, which is expected to have a significant positive effect on their behavioral intention and IT usage (Davis, Bagozzi, and Warshaw 1989). Though not formally a part of PAM, attitude and its determinants (i.e., usefulness and ease of use) were measured in this study to test the TPB model in its pure form and subsequent to addition of PAM constructs as described in Chapter III. Attitude was measured perceptually in this study using a three-item scale in the pre-treatment questionnaire (see Appendix A). The scale was taken from Taylor and Todd (1995), modified to reflect SOLVER usage in the current experimental context. This scale was reported to have a Cronbach alpha of 0.85, which was reassessed using data from this study (see Chapter V).

Usefulness and Ease of Use

The two most significant determinants of attitude, according to TAM, are usefulness and ease of use, which as perceived by potential users, positively impact on their attitude and thereby their IT usage behavior. Drawing from prior IT diffusion research, usefulness was operationalized in this study as the degree to which subjects perceived SOLVER as being better than its other IT or non-IT alternatives, such as calculators.

Likewise, ease of use was measured as the degree to which SOLVER was perceived as being easy to understand, learn, or operate. Both variables were measured using three-item perceptual measures adapted from Moore and Benbasat (1991) (see pre-treatment questionnaire in Appendix A), which are reported to have Cronbach alpha of 0.92 and 0.80 respectively.

Risk Aversion

This variable refers to subjects' risk attitude toward IT usage behavior, which is hypothesized to have a negative association with IT usage (see Chapter III). Measurement of risk attitudes in experimental economics has followed two contrasting approaches. The first approach, developed by Becker, DeGroot, and Marshak (1964), presents subjects with a set of lotteries (having different payoffs and a different probability for each payoff), and asks them to select the lottery that they would prefer. However, psychometric properties of such lotteries are difficult to evaluate and cognitive limitations arising from complex lottery choices may bias subjects' responses (Camerer 1995). A second and potentially more useful approach is based on Jackson Personality Inventory (Jackson, Houdnay, and Vidamer 1972), which measures subjects' risk attitudes from their response to a set of risky scenarios. This approach includes four modes of measurement, self-rating, situational dilemmas, vocational choice, and personality inventory, that attempt to tap at the underlying construct. Because of its simplicity, the Jackson et al. approach was used for assessing subjects' risk aversion in the current study (see Appendix A).

Incentive Level

This variable refers to the level of incentives (low versus high) provided to users for IT utilization, which is hypothesized to have a positive relationship with appropriate IT utilization. Incentive level was manipulated in this study by randomly preassigning subjects into "low incentive" and "high incentive" groups; subjects in the low incentive group received two bonus points toward their class grade for appropriately utilizing SOLVER, while those in the high incentive group received seven points. The magnitudes of points were based on a pilot study data, where subjects were asked what they would consider to be a reasonable incentive for the given task, and eleven of the twelve subjects agreed that 4 to 5 points would be adequate. It was therefore expected that a spread of five points (from two to seven) would constitute adequate incentives for the experimental task.

Manipulation of the treatment was checked using subjects' self-reported perceptions of incentive level, via a three-item, Likert-scaled measure on the pre-treatment questionnaire (see Appendix A). Also, as observed before, the perceptual measures rather than objective (dichotomous) measures was used for subsequent model testing and comparison, because it is widely believed that IT usage depends not on objective treatments but subjects' perceptions of these treatments (Moore and Benbasat 1991).

Incentive Type

This variable refers to whether incentives provided to users are based on their usage behavior or on the outcomes of such behavior. PAM claims that outcome-based incentives are generally more effective compared to behavior-based incentives in motivating appropriate IT usage because they make the user accountable for the realized outcomes. To test for the effect of this variable, the high incentive group was divided into "behavior-based incentive" and "outcome-based incentive" groups; subjects in the first group received bonus points depending on their utilization of SOLVER functionalities, irrespective of whether or not the assigned task was completed, while for subjects in the second group, the bonus points were based on the proximity of their recommended solution to the optimal solution in the budget allocation task[6], irrespective of their use or non-use of SOLVER (subjects in this group were still expected to utilize SOLVER because they were told that SOLVER offered a easy and convenient way of obtaining the optimal solution). Manipulation of this variable was achieved via random preassignment of subjects into treatment groups. In addition, the treatment was measured perceptually using a three-item measure prior to the experimental treatment (see Appendix) to assess the adequacy of treatment manipulation and for purposes of statistical analysis.

Monitoring

This variable relates to users' awareness of whether or not their behavior (appropriate IT usage) is being monitored by management. As discussed earlier, monitoring is perceived by users as revealing their behavior to management, which induces them to utilize the IT appropriately. Monitoring was operationalized in this study by dividing

[6] The optimal solution could be obtained directly by using SOLVER. However, reasonably close solutions (within about 10 percent of the optimal solution) were acceptable. The "goodness" of a solution was judged by the lack of deviation of the net order profit from the actual SOLVER profit. Subjects could achieve fairly reasonable solutions without utilizing SOLVER via Excel what-if analysis techniques or some simple heuristics.

subjects in the behavior-based incentive group into "monitoring" and "no monitoring" groups. Subjects in the monitoring group were informed that their utilization of SOLVER was being continuously monitored during the treatment using network auditing software, while those in the no monitoring group were told that their activities were not being monitored because of software limitations. Such operationalization of computer-based monitoring has been found adequate in prior research (e.g., Aiello 1993). Treatment manipulation is verified using a three-item perceptual measure on the pre-treatment questionnaire (see Appendix A), which was also used during subsequent data analysis.

Behavioral Evaluation Type

This variable refers to whether incentives offered to IT users are based on their absolute behavior or behavior relative to that of other users. Principal-agent research suggests that relative behavior based incentives are more effective in controlling for a common state of nature, and thereby reduces the adverse selection problem. Operationalization of this variable was achieved by randomly dividing the behavior-based incentive group into "absolute behavior-based" and "relative behavior-based" groups; subjects in the first subgroup were told that their reward would be based on their utilization of SOLVER evaluated on an absolute scale, while those in the second subgroup were informed that their SOLVER utilization would be evaluated on relative to other subjects in the same group. Like other variables, manipulation of this treatment was checked using a three-item perceptual measure (see pre-treatment questionnaire in Appendix A).

Repeated Contracts

This variable refers to whether users have the opportunity of securing favorable incentives in future periods based on their behavior in the current period. PAM postulates that users will be motivated to utilize IT appropriately if they expect better behavior to be rewarded in subsequent periods via repeated contracts. This variable was operationalized dichotomously as presence versus absence of repeated contracts, by randomly dividing the low incentive group into "single contract" and "repeated contract" groups. Subjects in both groups received two points for using IT in the current task; however those in the second group were told that they could get an extra five points for participating in a second task of similar type if they could utilize SOLVER appropriately in the current task, while those in the first group did not have any such opportunity. The low incentive group was selected for this purpose (as opposed to the high incentive group) in order to provide a greater equalization of the maximum incentive (seven points) available to the subjects. A multiple-item perceptual measure is used to verify the effect of this treatment on subjects (see Appendix A), and to test the hypothesized effect during data analysis.

Model Assumptions

The usefulness of the proposed principal-agent model in understanding intraorganizational IT usage is governed by the extent to which the assumptions of the model are valid. Some of the PAM assumptions (e.g., goal incongruence and risk aversion) were manipulated in this study as independent variables, while information asymmetry (i.e., moral hazard and adverse selection) was tested indirectly by examining the interactions of control mechanisms such as monitoring, behavioral evaluation type, and repeated contracts with subject behavior. The remaining assumptions, rationality and self-interest, were measured and tested explicitly for their validity. An additional voluntariness assumption was also tested because implementation research holds that for IT usage to be a useful surrogate for implementation success, usage must be voluntary (Lucas 1975).

As noted in Chapter III, the concept of *rationality* is based on three theoretical axioms of expected utility theory: ordering, continuity, and independence (Von Neumann and Morgenstern 1944). In experimental economics, rationality is typically tested by examining individual axioms via lotteries of subjects' preferences (i.e., a set of possible outcomes with different probabilities). Although psychometric properties of these lotteries are not available, they are found to be reasonably consistent in estimating individual rationality (Thaler 1987). In this study, a three-item scale using lotteries taken from Camerer (1995) was employed to assess the axioms of rationality (see post-treatment questionnaire in Appendix A).

Similar to rationality, very few prior implementation/diffusion studies have attempted to measure *self-interest*, instead this assumption is typically verified using anecdotal evidence (e.g., Francik, Rudman, Cooper, and Levine 1991). In the current study, a three-item perceptual scale was developed, based on the guidelines of Ajzen and Fishbein (1980), to elicit subjects' perception of self-interested behavior (see post-treatment questionnaire in Appendix A).

Finally, the *voluntariness* assumption was measured in this study for empirical testing using a three-item, Likert-scaled perceptual measure adapted from Moore and

Benbasat (1991), which is reported to have a Cronbach alpha of 0.82 (see post-treatment questionnaire in Appendix A).

4.4 Summary

The purpose of this chapter was to discuss methodological issues concerning the empirical testing of the research model presented in Chapter III. A laboratory experiment was designed for that purpose, which is outlined in this chapter. The experimental approach was justified in light of the fundamental tradeoff between internal and external validity in scientific inquiry, given this study's focus on internal validity (causality) in an area where theory-building has been minimal.

Students from a computer applications class at a large southwestern university served as subjects for this laboratory experiment. Subjects were awarded bonus points toward their class grade as incentives for solving a complex budget allocation problem that could potentially benefit from the use of IT. Microsoft Excel's SOLVER tool was the IT recommended for performing this task, though subjects were free to use any IT or non-IT of their choice. The task situation and IT were introduced to subjects prior to the experiment via an in-class demonstration and a written tutorial. The incentive and control structures were manipulated by categorizing subjects into different treatment groups.

The research design employed in this study was a multi-group posttest only design with six treatment groups. The treatment groups were unique combinations of the five incentive and control structures examined in this study (i.e., incentive level, incentive type, monitoring, behavioral evaluation type, and repeated contracts), operationalized in dichotomous terms (e.g., low versus high, present versus absent). Subjects' perceptions of these treatments were elicited via a pre-treatment questionnaire, intended to first check for treatment manipulations, and then for model testing and comparison. The same questionnaire was used to also measure risk aversion and perceptual measures of TPB variables (i.e., behavioral intention, attitude, subjective norm, usefulness, and ease of use) that were also examined in this study in an attempt to isolate the explanatory power of PAM variables within an overall TPB framework. On completion of the task, subjects were administered a post-treatment questionnaire intended to capture perceptual measures of IT usage (operationalized as acceptance and infusion), and model assumptions (i.e., rationality, self-interest, and voluntariness). IT usage was also determined objectively by examining these diskettes turned in by subjects after the task, as well as by using a LAN auditing software package. Operationalization and measurement of each of these variables and assumptions were discussed.

Two pilot studies and one experimental study were conducted to examine the feasibility of the laboratory experiment, to psychometrically validate the research instrument, to test the causal linkages in the proposed model, and to compare the explanatory power of the proposed model with that of similar IT usage models. Details concerning the pilot and experimental studies and their results are presented in the next chapter.

Chapter V

DATA ANALYSIS AND RESULTS

"Measurement consists of rules to assign numbers to objects in such as way as to represent quantities of attributes" (Nunnally 1978, p. 3). Measurement serves four useful purposes in social science research: (1) it provides a basis for scientific observation and generalization, (2) it allows utilization of statistical tools and formalized procedures for testing causality, (3) it enables comparison of empirical results across studies, and (4) it is more economical of time and money than subjective evaluations (Nunnally 1978, p. 5-9). Measurement of variables and analysis of these measurements were conducted in the current research using two pilot studies and one experimental study. This chapter presents results from these studies.

The chapter proceeds as follows. The first section describes the latent variable modeling (LVM) approach, and a specific LVM technique called partial least squares (PLS), used for data analysis in the current study. The second section describes results from the pilot studies and how they were used to refine the experimental procedures. Psychometric validation of research instruments is presented in the third section. The fourth section describes sample demographics, checks for treatment manipulation, and tests model assumptions. Section five uses the PLS approach to test the proposed model of intraorganizational IT usage and to isolate the explanatory power accorded by principal-agent constructs. The final section summarizes the major findings of the study and discusses their implications for understanding intraorganizational IT usage.

5.1 Latent Variable Modeling

Latent variable modeling (LVM), also called confirmatory modeling or structural equation modeling, of unobservable "latent" variables is rapidly becoming an exciting growth area in social science research (Loehlin 1987, Harris and Schaubroeck 1990). LVM represents the convergence of relatively independent research traditions in psychometrics, econometrics, and biometrics, dating back to the 1930's (Bentler 1982). Recent interest in this area has been fueled by theoretical advances in second generation multivariate statistical techniques and availability of sophisticated computer software. While traditional first generation multivariate techniques (e.g., MANOVA) rely solely on observed data for knowledge building or testing, the newer second generation approaches (e.g., LISREL, EQS, and PLS), constituting the core of LVM, are based on the recognition that knowledge building involves both abstract theoretical reasoning and empirical measurement (Fornell 1989). A fundamental objective of LVM is therefore to bring abstract theory and empirical data together, and thereby, "offer a potential of scientific explanation that goes far beyond description and empirical association" (Fornell 1989). This section presents a brief background of the LVM approach, compares two LVM techniques used widely in social science research (i.e., LISREL and PLS), and presents a mathematical specification of the model used in PLS analysis.

5.1.1 Background

Latent variables are "hypothetical constructs invented by a scientist for the purpose of understanding a research area; generally there exists no operational method for directly measuring these constructs" (Bentler 1982). Examples of such variables in the current study include attitude, risk aversion, and behavioral intention. These unobservable variables are measured indirectly using observable indicators or manifest variables, typically in the form of multiple-item scales.

Latent and manifest variables may be linked to one another via a set of relationships, and a system of such relationships constitute a causal model. Relationships can be of two types: (1) *outer relations*: associations between latent variables and manifest variables purporting to measure them, and (2) *inner relations*: associations among different latent variables (Fornell and Bookstein 1982). Outer relations may be reflective, if the unobserved construct is believed to give rise to the observed data, or formative, if the empirical indicators give rise to the underlying construct (Fornell and Bookstein 1982). Within inner relations, some latent variables may be designated as predictor (independent) or exogenous variables, while others are designated as response (dependent) or endogenous variables for purposes of causal analysis.

The system of outer relations constitute the *measurement model* in LVM, while that of inner relations comprise the *structural model.* The structural model is postulated by the theory employed by the researcher, while the measurement model is defined via rules of correspondence or "auxiliary theories" and provide the linkage between theory and data (Bentler 1992). Though the structural model is of direct interest to social science researchers interested in model testing and/or comparison, the measurement model is also of critical importance in confirmatory research because it offers a convenient way of validating the research instrument used for measuring latent variables in the model. The robustness of latent variables depends on the reliability and representativeness of the measuring indicators, hence the measurement model can be used for instrument validation.

Latent variable models can be graphically illustrated using path diagrams (Loehlin 1987), where latent variables (theoretical constructs) are depicted using circles and manifest variables (empirical indicators) are represented by squares. Relationships are indicated using arrows connecting these variables; reflective indicators are represented as arrows from latent to manifest variables, while the directionality is reversed for formative indicators. Path diagrams of TPB, excluding and including PAM constructs, are presented in Figures 5.2 and 5.3 respectively (the manifest variables are not shown for purposes of clarity). Parameters in these path models can be estimated using covariance-based approaches such as LISREL (Joreskog 1993) or variance-based approaches such as PLS (Wold 1981), which are compared in the next section.

5.1.2 Comparison of LVM Approaches

Of the different approaches of estimating latent variable models, linear structural relations (LISREL) seems to be the most popular (e.g., Taylor and Todd 1995). However, partial least squares (PLS) may be a more powerful alternative because of the minimal demands it places on residual distributions, measurement scales, and sample sizes (Fornell and Bookstein 1982, Igbaria, Guimaraes, and Davis 1995). Unlike LISREL, PLS is distribution-free (i.e., it does not require empirical data to have multivariate normal distribution), it can be used even with non-interval scaled data, and most importantly, it can utilize small samples (Igbaria, Guimaraes, and Davis 1995). For instance, if the number of measured indicators in a model is N, LISREL would require a sample size of 1.5*N*(N+1), while a the corresponding sample size required in PLS is between 5*N (a weak rule of thumb) and 10*N (a strong rule of thumb) (Bentler 1982). Furthermore, PLS can handle large models with as many as 100 indicators.

While LISREL employs covariance-based full information approaches (e.g., maximum likelihood or generalized least squares) leading to simultaneous estimation of all parameters, PLS employs a limited information, variance-fitting approach (ordinary least squares) where parameters are estimated in blocks separated from one another (Harris and Schaubroeck 1990). Bias in the estimate of one parameter is therefore less likely to affect estimates of other parameters, and hence, PLS is less affected by multicollinearity. However, as a limited information model, PLS parameter estimates are less than optimal regarding bias and consistency, though these estimates will be asymptotically correct under large sample sizes.

The most important distinction between LISREL and PLS is that while factors-based LISREL is more appropriate in areas where prior theory is strong and further theory testing and development is the goal, the component-based PLS is more suited to areas where the theory is weak or tentative (Fornell and Bookstein 1982). According to Joreskog and Wold (1982, p. 270), "[LISREL] is theory-oriented, and emphasizes the transition from exploratory to confirmatory analysis. PLS is primarily intended for causal, predictive analysis in situations of high complexity but low theoretical information."

Given the initial stage of theory development in the area of incentives and control and the limited sample size in this study (132 observations for 43 indicators and 15 constructs), PLS was considered a better choice than LISREL for examining causal linkages in the proposed principal-agent model of IT usage.

5.1.3 Mathematical Specification of PLS

Developed by Herman Wold (1981) as an extension of his theory of fixed-point estimation, PLS is a variance-based approach where indicator loadings and structural parameters are estimated using an iterative ordinary least squares method. In this approach, the set of model parameters is divided into subsets, which are estimated separately via ordinary multiple regressions involving the values of parameters in other subsets (Fornell and Bookstein 1982). Latent variables are estimated as exact linear combinations of the manifest variables, thereby providing an assessment of the measurement model in conjunction with the structural model, in form of confirmatory factor analysis. PLS provides a general multivariate model that encompasses a suite of multivariate techniques such as canonical correlation, redundancy analysis, multiple regression, multiple analysis of variance, and principal components analysis.

A PLS model can be mathematically specified as follows (Fornell and Bookstein 1982). The measurement model (outer relations) is represented as a system of simultaneous linear equations:

$$y = \Lambda_y \eta + \varepsilon$$

$$x = \Lambda_x \xi + \delta$$

where $\eta^T = (\eta_1, \eta_2, \ldots, \eta_m)$ and $\xi^T = (\xi_1, \xi_2, \ldots, \xi_n)$ are vectors representing the unobserved latent variables (endogenous and exogenous respectively), $y^T = (y_1, y_2, \ldots, y_p)$ and $x^T = (x_1, x_2, \ldots, x_q)$ are manifest variables used to measure the above latent variables, Λ_y and Λ_x are the corresponding regression matrices of order (p x m) and (q x n), and ε and δ are the residual vectors. The structural model (inner relations) can then be specified as:

$$\eta = \beta\,\eta + \Gamma\,\xi + \zeta$$

where β is a (m x m) matrix of coefficient parameters for η (with zeros along the diagonal), Γ is a (m x n) coefficient matrix for ξ, and ζ is the residual vector for endogenous variables η, given as $\zeta = \eta - E(\eta)$.

Predictor specification in the measurement model implies $E(\varepsilon) = E(\delta) = E(y\,\varepsilon^T) = E(x\,\delta^T) = 0$. The η and ξ vectors are standardized such that $E(\eta) = E(\xi) = 0$ and Var

(η_i) = Var (ξ_j) = Var (x_k) = Var (y_l) = 1 for all i, j, k, and l. For convenience, x and y are also standardized such that E (x) = E (y) = 0. Finally, the following variance-covariance matrices are defined: E $(\varepsilon\,\varepsilon^T) = \theta_\varepsilon$, E $(\delta\,\delta^T) = \theta_\delta$, E $(\xi\,\xi^T) = \varphi$, E $(\zeta\,\zeta^T) = \psi$. Given these assumptions, the unobservable latent variables may be estimated as exact linear combinations of their empirical indicators:

$$\eta = \pi_\eta\, y$$

$$\xi = \pi_\xi\, x$$

where π_η and π_ξ are regression matrices of order (p x m) and (q x n) respectively. Likewise, for the structural model, E (ζ) = E $(\eta\zeta^T)$ = E$(\xi\zeta^T)$ = 0, such that:

$$E\,(\eta \mid \eta, \xi) = \beta^{*}\eta + \Gamma\,\xi$$

Whether to adopt a measurement model of the form $y = \Lambda_y\,\eta$ or $\eta = \pi_\eta\, y$ depends on whether the empirical indicators are conceptualized as reflective or formative. The choice between reflective and formative indicators should be derived from auxiliary theories used to operationalize the construct (Lohmoller 1989) and justified based on the research objective and empirical considerations. When the objective is to predict manifest variables, the need to minimize residuals in these indicators would suggest the use of reflective indicators. Conversely, if the objective is to examine theoretical relationships among constructs, the desire to minimize residuals in the structural equations would suggest formative indicators. Finally, reflective indicators are estimated using simple bivariate regression and are therefore unaffected by multicollinearity, while formative indicators employ multiple regression where multicollinearity among indicators can affect the stability of the derived parameters. Given these considerations, reflective indicators were considered appropriate for all variables in the current study.

As indicated before, the above system of equations is estimated in PLS using an ordinary least squares approach. Though PLS provides estimates of path coefficients (standardized beta's between the predictor and response variables) for the structural model, it does not directly provide any statistical measure of significance for these estimates. Standard errors or t-statistic of path coefficients can be reestimated via resampling procedures such as jackknifing or bootstrapping (Efron 1982). In the jackknife procedure, random subsamples are drawn from the original data set by dropping one or more observations, parameter estimates are derived using these subsamples, which are then used to fit the deleted observations. In the bootstrap procedure, the subsample is drawn "with replacement" from the original sample, prior to estimation and fitting. It has been argued that bootstrapping is more robust and generalized of the two procedures (Chin and Frye 1995), and was therefore selected in this study for computing the significance of path estimates.

5.2 Pilot Studies

Data for the current research was collected in three phases: a small-scale pilot study, followed by a full-scale pilot and the actual experimental study. Subjects in both pilot studies were drawn from a common pool of subjects enrolled in a computer applications class in the same semester, while the experimental study was conducted using subjects enrolled in the same class in the following semester. The first pilot utilized a sample of twelve student subjects who were familiar with the use of Microsoft Excel (but not with SOLVER) prior to the start of the semester. This pilot was intended to serve three purposes: (1) to examine the reasonableness of the task and IT for the subject sample, (2) to identify potential improvements in experimental procedures, and (3) to qualitatively assess an initial version of the research instrument. The second pilot, conducted later in the same semester, employed a sample of 71 subjects and was primarily directed at psychometric evaluation of different scales in the research instrument.

The small sample size in the first pilot was not of significant concern since it was aimed at exploring the overall feasibility of the research project and was intended to be followed by a "full-scale" pilot study. However, given its size, the sample was not divided into treatment groups and the data was not subjected to any statistical analysis. Suggestions from subjects were used to refine the tasks, questionnaires, and administrative procedures for the subsequent pilot and experimental studies.

Subjects in the first pilot confirmed that the task (budget allocation problem) and IT (Microsoft Excel's SOLVER tool) were reasonable for students in this class. Despite employing subjects who were more advanced compared to the rest of the class (since they were familiar with the use of Microsoft Excel prior to the start of the semester), only one subject was aware of the availability of the SOLVER tool (but did not know how to use it). This confirmed that the selected IT was indeed new for the subject sample and was therefore a reasonable choice for examining their IT usage behavior.

On the average, subjects took between twenty minutes and two hours to complete the assigned task, with an average of one hour and fifteen minutes. Therefore, two hours was considered a reasonable time allotment for the experimental task. However, in order to eliminate any potential confounding effect of time pressure, it was decided that subjects unable to complete the task within the allocated time would be allowed to continue working as long as they needed in order to complete the assigned task.

Experiences from the first pilot also helped improve some of the administrative procedures in the experiment. For example, subjects felt that written instructions on using SOLVER would be useful, since this topic was not covered in the course textbook. Therefore, subjects in the second pilot and experimental studies were provided with a written tutorial in addition to the in-class demonstration prior to the treatment.

Subjects in the first pilot were also administered an initial version of the pre-treatment and post-treatment questionnaires, and their responses were assessed qualitatively. The goal was to obtain scales for each construct that were simple, understandable, and parsimonious. Individual items in these scales were adapted from prior research or created by the researcher based on the operational definition of the construct, and then randomly ordered into a common pool. Respondents were asked to first complete the questionnaire and then comment on its length, wording, and instructions. Many subjects felt that the questionnaires were too long and that several items seemed ambiguous. Based on subsequent discussion with these subjects, the ambiguous items were either re-worded or eliminated. The final version of the instrument had 3 to 4 items per construct.

Psychometric evaluation of the different scales was done in the second pilot and the actual experimental study, and is described in the next section of this chapter.

5.3 Instrument Validation

Instrument validation is one of the most important processes in confirmatory empirical research because the quality of the instrument determines the extent to which the results obtained are accurate and meaningful (Cook and Campbell 1979). Because MIS research deals largely with behavioral constructs that are not directly observable, psychometric validation of instruments is of paramount importance. Two common forms of instrument validation are reliability and construct validity (Nunnally 1978). However, following a survey of instruments used in 117 empirical studies in MIS, Straub (1989) observed that 83 percent of instruments used did not test for reliability and 62 percent did not have any single form of validation.

Straub (1989) recommended three guidelines for developing instruments in empirical MIS research: (1) pretest and pilot test instruments, (2) use previously validated instruments wherever possible, and (3) triangulate measurements using dissimilar methods to isolate common variance. The two pilot studies in this research can be viewed respectively as a pretest and pilot test, as suggested by Straub. Previously developed scales with validated psychometric properties (e.g., Moore and Benbasat 1991, Mathieson 1991, Taylor and Todd 1995) were employed wherever possible. Finally, several model variables were measured both objectively and perceptually to enable triangulation.

In addition, reliability and construct validity were evaluated for each scale in the pre-treatment and post-treatment questionnaires using a sequence of three statistical approaches: correlational analysis, exploratory factor analysis, and confirmatory factor analysis, performed on data collected from the second pilot and experimental studies. Such sequence can be viewed as a cumulative approach in instrument validation, which has been urged in MIS research in order to improve the rigor of empirical analysis (Subramanian and Nilakanta 1994). Details concerning these tests are described next.

5.3.1 Scale Reliabilities

Reliability of a scale is a measure of its stability or consistency, i.e., the extent to which the measurements obtained using the scale are free from systematic error (Kerlinger 1986). Using the analogy of a bulls eye target, reliability refers to the lack of scatter of shots on the target. The most widely used measure of reliability is internal consistency, though test-retest reliability and inter-rater reliability are also sometimes used. *Internal consistency* refers to the degree of homogeneity or cohesiveness among items purporting to measure the same construct (Subramanian and Nilakanta 1994). This is typically measured using Cronbach's alpha on a scale from 0 to 1, calculated from a matrix of inter-item correlations. Although Cronbach alphas of 0.50 to 0.60 may suffice for exploratory research, a minimum of 0.80 is recommended for instruments used in confirmatory research (Nunnally 1978). However, as Nunnally argued, "increasing reliabilities beyond 0.80 is often wasteful." Hence, the target reliability for each scale in this study was set at 0.80.

Table 5.1. Scale reliabilities (internal consistencies) for perceptual variables

Scale	*# of items*	*Mean*	*Std. Dev. (pooled)*	*Cronbach Alpha*
Model variables:				
Perceived Acceptance	3	0.621	0.365	0.831
Perceived Infusion**	3	4.982	2.146	0.796
Behavioral intention	3	5.328	1.683	0.893
Attitude	3	5.408	1.690	0.836
Subjective norm	3	5.326	1.775	0.816
Usefulness	3	6.004	1.298	0.842
Ease of use	3	4.626	1.763	0.805
Risk aversion	4	5.273	2.269	0.698
Incentive level	3	4.580	2.061	0.906
Incentive type	3	3.611	2.205	0.784
Monitoring	3	4.134	2.119	0.864
Behavioral evaluation type	3	3.596	2.138	0.775
Repeated contract	3	2.843	2.177	0.867
Model assumptions:				
Rationality*	3	-	-	-
Self-interest	3	5.610	1.226	0.727
Voluntariness	3	5.273	2.269	0.909

** One item (IN3) was removed from the perceived infusion scale.
*The rationality scale consisted of three uncorrelated binary items and was therefore not examined.

Scale reliabilities were calculated in this study using Statistical Analysis System (SAS) for Windows, Release 6.08. PROC CORR was used in SAS with the ALPHA option to generate inter-item correlations and Cronbach alpha for each scale[1]. Means, standard deviations, and Cronbach alphas for the different scales are listed in Table 5.1, and correlation tables used to compute these reliabilities are provided in Table 5.2. As indicated in Table 5.1, eleven of fifteen model variables/assumptions met the target reliability level of 0.80, with the exception of incentive type ($\alpha = 0.78$), risk aversion ($\alpha = 0.70$), behavioral evaluation type ($\alpha = 0.78$), and self-interest ($\alpha = 0.73$), all of which were reason-

[1] Note that Cronbach alpha can also be computed for each scale using the formula $\alpha = N^*\rho \,/\, [1+ \rho\,(N-1)]$, where N is the number of items in the scale and ρ is the mean inter-item correlation among scale items (Carmines and Zeller 1979, p. 44).

Table 5.2 Pearson's correlation coefficients among indicators

	IL1	IL2	IL3	IT1	IT2	IT3	MN1	MN2	MN3
IL1	1.000								
IL2	0.792	1.000							
IL3	0.743	0.751	1.000						
IT1	-0.153	-0.084	-0.101	1.000					
IT2	-0.209	-0.170	-0.209	0.367	1.000				
IT3	-0.068	-0.041	0.005	0.527	0.146	1.000			
MN1	-0.252	-0.193	-0.198	0.184	0.340	0.199	1.000		
MN2	-0.257	-0.227	-0.165	0.124	0.311	0.113	0.689	1.000	
MN3	-0.294	-0.233	-0.159	0.180	0.217	0.204	0.666	0.683	1.000

	BE1	BE2	BE3	RC1	RC2	RC3	BI1	BI2	BI3
BE1	1.000								
BE2	0.326	1.000							
BE3	0.512	0.366	1.000						
RC1	-0.058	-0.227	-0.056	1.000					
RC2	-0.063	-0.187	0.044	0.837	1.000				
RC3	-0.011	-0.085	-0.138	0.630	0.584	1.000			
BI1	-0.048	-0.081	-0.122	0.003	0.012	-0.054	1.000		
BI2	-0.084	-0.071	-0.183	0.017	-0.032	0.004	0.805	1.000	
BI3	-0.077	-0.079	-0.185	0.016	-0.035	-0.045	0.658	0.739	1.000

	SI1	SI2	SI3	VL1	VL2	VL3	RA1	RA2	RA3	RA4
SI1	1.000									
SI2	0.384	1.000								
SI3	0.162	0.163	1.000							
VL1	0.019	0.000	-0.070	1.000						
VL2	0.064	0.106	-0.143	0.732	1.000					
VL3	0.103	0.118	-0.096	0.701	0.870	1.000				
RA1	0.046	0.048	0.066	0.068	0.007	-0.003	1.000			
RA2	0.075	0.143	0.098	0.012	-0.059	-0.104	0.153	1.000		
RA3	-0.069	-0.137	-0.027	-0.089	-0.142	-0.149	0.272	0.277	1.000	
RA4	-0.045	0.083	0.265	-0.162	-0.171	-0.190	0.176	0.293	0.297	1.000

	US1	US2	US3	EU1	EU2	EU3	SN1	SN2	SN3
US1	1.000								
US2	0.624	1.000							
US3	0.635	0.663	1.000						
EU1	0.421	0.304	0.510	1.000					
EU2	0.283	0.222	0.329	0.643	1.000				
EU3	0.152	0.074	0.280	0.380	0.414	1.000			
SN1	0.228	0.182	0.159	0.355	0.313	0.243	1.000		
SN2	0.167	0.199	0.166	0.268	0.236	0.250	0.360	1.000	
SN3	0.151	0.194	0.099	0.249	0.159	0.087	0.394	0.332	1.000

	AT1	AT2	AT3	AC1	AC2	AC3	IN1	IN2	IN3	IN4
AT1	1.000									
AT2	0.709	1.000								
AT3	0.540	0.639	1.000							
AC1	0.056	0.355	0.221	1.000						
AC2	0.235	0.112	0.339	0.656	1.000					
AC3	0.113	0.121	0.241	0.776	0.671	1.000				
IN1	0.439	0.304	0.228	0.336	0.436	0.343	1.000			
IN2	0.425	0.310	0.219	0.532	0.425	0.242	0.860	1.000		
IN3	0.094	0.110	0.095	0.123	0.231	0.311	0.065	0.064	1.000	
IN4	0.371	0.269	0.290	0.302	0.238	0.221	0.453	0.289	0.385	1.000

ably close to the target figure. The rationality scale was excluded from this analysis because this scale consisted of three binary items that examined different dimensions of rationality that were not expected to be correlated.

Of particular interest was the perceived infusion measure, where one item (IN3: "In this assignment, I used all functionalities in SOLVER to the fullest extent possible") had very poor correlation with the remaining scale items (see Table 5.2). A closer examination of this item revealed that while other infusion items measured "appropriateness" of IT utilization, IN3 attempted to measure "completeness" of IT utilization. Because complete utilization of SOLVER was not required for the performing well in experimental task, this item demonstrated a poor fit with other infusion items and was therefore deleted from subsequent analysis. Deletion of item IN3 led to an increase in Cronbach alpha from 0.68 for the original four-item perceived infusion scale (including IN3) to 0.80 for the remaining three-item scale.

5.3.2 Scale Validities

The validity of a scale refers to the extent to which it measures what it is purported to measure, and not, say, some artifact of the instrument (Kerlinger 1986). The most useful and common form of validity is construct validity, while content validity and criterion-related validity are also sometimes examined. *Content validity* refers to the representativeness or sampling accuracy of the content, i.e., whether the scale adequately covers the entire domain of interest. Nunnally (1978) recommended using prevalidated measures and a minimum of three items per scale for adequate content validity. In this study, each scale comprised of 3 to 4 items. Furthermore, previously validated scales were used for most scales. For other scales (e.g., incentive level), items were developed based on theoretical definition of the underlying construct.

Construct validity examines how well individual items of an scale correspond to the intended construct. Two forms of construct validity are convergent and discriminant validity. *Convergent validity* measures the degree of association (e.g., correlation) between one construct and items purporting to measure it, while *discriminant validity* refers to the lack of association between one construct and items belonging to other constructs (Subramanian and Nilakanta 1994). Both forms of construct validity can be assessed using factor analysis. Convergent validity is ascertained if individual items hypothesized to measure a single construct load highly on a common factor, while discriminant validity is established if the same items load poorly on other factors (Kim and Mueller 1978).

Factor analysis can be exploratory or confirmatory, depending on the objectives of the researcher. The goal of exploratory factor analysis (EFA) is to uncover the underlying factor structure from observed data. The covariance structure of observed indicators is used to aggregate these indicators into a smaller set of factors (called the common factor model), which is expected to reflect the underlying constructs. In comparison, the goal of confirmatory factor analysis (CFA) is to cross-validate a hypothesized factor structure by combining theory with data. In CFA, the researcher has some ex ante beliefs regarding the expected factor structure (typically derived from auxiliary theories), and examines whether the observed data structure deviates significantly from this hypothesized structure. The expected factor structure is specified in form of a linear system of equations, the covariance structure derived from this structure is matched against that derived from observed data, and the degree of match is used to iteratively refine the hypothesized model.

In this study, both exploratory and confirmatory factor analysis were employed for assessing construct validity of the research instrument. EFA was conducted using PROC FACTOR in SAS on data collected from the second pilot study to identify potential factor patterns. This pattern was used to refine the measurement scales. The refined instrument was then subjected to CFA using a partial least squares program called PLS-Graph (Chin and Frye 1995) on data from the actual experimental study. Though CFA is a more rigorous technique for instrument validation compared to EFA, an incorrectly specified factor structure may introduce bias in the sample CFA estimates, leading to incorrect factor loadings. EFA is less likely to be affected by theoretical biases because factor extraction is based purely on observed data. EFA is therefore more appropriate in the initial stages of instrument development, while CFA is more justified in the later stages. A combination of both approaches, as employed in this study, can be viewed as a cumulative approach in instrument validation (Subramanian and Nilakanta 1994).

For exploratory factor analysis, 46 items in the original instrument were pooled into two sets of 24 and 22 items (to make the data set more manageable) and factor analyzed separately. The first group consisted of items derived from principal-agent research (i.e., behavioral intention, incentive level, incentive type, risk aversion, monitoring, behavioral evaluation type, and repeated contract), while the second group consisted of TPB constructs and model assumptions (i.e., perceived acceptance, perceived infusion, subjective norm, attitude, usefulness, ease of use, self-interest, and voluntariness). Actual acceptance and infusion were single-item objective scales, and were therefore excluded from the analysis. Likewise, the rationality scale consisted of three binary items measuring different and uncorrelated dimensions of the construct. These measures were not expected to co-vary, and were therefore not examined.

EFA involves three fundamental steps: (1) preparing an initial covariance matrix, (2) extracting the common factor model, and (3) rotating factors to a terminal solution (Kim and Mueller 1978). A correlation (ordinary covariance) matrix was constructed for each data set, which served as the input to the factor extraction phase. The common factor model was extracted using principal component analysis, a variance-maximizing procedure which extracts components (factors) such that the each component explains maximum residual variance in sample data not explained by previously extracted components. The adequacy of factor extraction was checked in two ways: (1) by visually inspecting scree plots of extracted factors (ignoring factors lying beyond the elbow region of the plot), and (2) by selecting factors with a minimum eigenvalue of 1.0. Both criteria indicated that the identified factors were adequate. Eigenvalues for each factor extracted are given in Table 5.3.

The initial factor model was then subjected to PROMAX rotation to identify an unambiguous factor structure. PROMAX is an oblique rotation technique and is a more conservative approach compared to more widely used orthogonal techniques because it does not arbitrarily impose the restriction that factors be uncorrelated. In case the resulting factors are found to be orthogonal after rotation, it is assured that orthogonality is not

Table 5.3 Construct validity using exploratory and confirmatory factor analysis

Variable	*Item*	*Factor loading (EFA)*	*Factor loading (CFA)*	*Eigenvalue*	*Variance extracted*
Model variables:					
Perceived acceptance	AC1	0.783	0.851	1.036	0.732
	AC2	0.721	0.860		
	AC3	0.549	0.635		
Perceived infusion	IN1	0.912	0.850	6.070	0.711
	IN2	0.913	0.844		
	IN4	0.880	0.792		
Actual acceptance	ACA	-	-	-	-
Actual infusion	INA	-	-	-	-
Behavioral intention	BI1	0.907	0.915	2.899	0.844
	BI2	0.936	0.945		
	BI3	0.870	0.896		
Incentive level	IL1	0.903	0.935	4.051	0.851
	IL2	0.902	0.916		
	IL3	0.896	0.917		
Incentive type	IT1	0.849	0.814	1.308	0.565
	IT2	0.409	0.803		
	IT3	0.827	0.622		
Monitoring	MN1	0.855	0.924	2.464	0.808
	MN2	0.908	0.866		
	MN3	0.858	0.907		
Behavioral evaluation type	BE1	0.839	0.787	1.439	0.620
	BE2	0.625	0.745		
	BE3	0.820	0.827		
Repeated contract	RC1	0.943	0.889	2.190	0.837
	RC2	0.970	0.913		
	RC3	0.761	0.942		
Subjective norm	SN1	0.519	0.812	1.223	0.623
	SN2	0.799	0.657		
	SN3	0.740	0.662		
Attitude	AT1	0.742	0.914	1.573	0.757
	AT2	0.859	0.913		
	AT3	0.872	0.776		
Risk aversion	RA1	0.477	0.624	1.547	0.394
	RA2	0.663	0.552		
	RA3	0.629	0.874		
	RA4	0.714	0.344		
Usefulness	US1	0.822	0.884	1.914	0.804
	US2	0.829	0.879		
	US3	0.800	0.925		
Ease of use	EU1	0.745	0.878	1.340	0.698
	EU2	0.812	0.864		
	EU3	0.529	0.759		
Model assumptions:					
Rationality	RN1	-	0.744	-	0.362
	RN2	-	0.407		
	RN3	-	0.798		
Self-interest	SI1	0.794	0.826	1.111	0.522
	SI2	0.795	0.840		
	SI3	0.405	0.798		
Voluntariness	VL1	0.877	0.879	2.808	0.895
	VL2	0.940	0.949		
	VL3	0.927	0.945		

Note: EFA was done seperately for two sets of variables: PAM constructs: incentive level, incentive type, behavioral intention, monitoring, repeated contracts, risk aversion, and behavioral evaluation type; and other model variables: perceived acceptance, perceived infusion, subjective norm, attitude, usefulness, ease of use, self-interest, and voluntariness. Actual acceptance and infusion were single-item objective scales, and rationality consisted of three uncorrelated binary measures, and were therefore not tested.

Table 5.4 Factor structure identified using exploratory factor analysis

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6	FACTOR7
IL1	0.9033	0.2825	-0.3077	-0.1144	-0.0522	0.2272	-0.1875
IL2	0.9016	0.1385	-0.2507	-0.1229	-0.0324	0.2670	-0.1080
IL3	0.8957	0.0463	-0.1994	-0.1561	0.0850	0.2056	-0.0888
IT1	-0.2033	0.0478	0.1678	0.1114	-0.2318	-0.0051	0.8488
IT2	-0.2909	0.0569	0.4035	0.0854	-0.5376	0.0313	0.4089
IT3	-0.0277	-0.0398	0.1625	0.0076	0.1279	-0.2371	0.8272
MN1	-0.2609	-0.2288	0.8554	-0.0623	-0.1795	-0.2153	0.2170
MN2	-0.2241	-0.0414	0.9083	0.0027	-0.1048	-0.1643	0.0912
MN3	-0.2501	-0.1875	0.8580	-0.0522	0.0104	-0.0809	0.2068
BE1	0.2074	-0.0675	-0.1534	-0.0411	-0.1384	0.8389	-0.1765
BE2	0.1846	-0.0922	-0.3214	-0.2596	0.2883	0.6247	0.1562
BE3	0.2533	-0.1657	-0.0574	-0.0215	0.0316	0.8207	-0.1549
RC1	-0.1353	0.0314	-0.0428	0.9437	-0.1290	-0.1124	-0.0110
RC2	-0.1063	0.0018	0.0771	0.9200	-0.1575	-0.0395	0.0161
RC3	-0.2001	-0.0365	-0.1285	0.7613	-0.2682	-0.0744	0.2000
BI1	0.1558	0.9072	-0.1616	0.0192	-0.1507	-0.0917	-0.1224
BI2	0.1789	0.9358	-0.1903	-0.0029	-0.0751	-0.1452	0.0318
BI3	0.0894	0.8703	-0.0802	-0.0144	0.0512	-0.1308	0.0494
RA1	-0.2087	0.0847	0.0417	-0.1487	0.4769	-0.2262	0.0120
RA2	0.1754	-0.0914	0.0353	-0.0767	0.6632	-0.0561	-0.1731
RA3	-0.1520	-0.1506	-0.0164	-0.2837	0.6289	0.0358	0.1367
RA4	-0.0025	0.0061	-0.1981	-0.0447	0.7141	0.1522	0.0221

	FACTOR1	FACTOR2	FACTOR3	FACTOR4	FACTOR5	FACTOR6	FACTOR7	FACTOR8
SI1	0.1775	0.0456	0.0939	0.1802	0.1731	0.0977	0.7943	0.1122
SI2	-0.0290	0.0871	-0.0155	0.1415	0.0721	0.0279	0.7953	0.2326
SI3	-0.2917	-0.1922	-0.3134	0.1558	0.5430	0.0928	0.4045	0.1212
VL1	-0.1335	0.8773	-0.1183	-0.0248	0.1058	0.1930	-0.0443	0.1013
VL2	-0.0737	0.9397	-0.0617	0.0583	-0.0373	-0.0868	0.0544	-0.0665
VL3	-0.1081	0.9276	-0.0377	0.1100	0.0344	-0.0462	0.0823	-0.0251
US1	0.4512	-0.0632	0.8222	0.3039	0.2256	0.1396	-0.0386	0.3645
US2	0.3179	-0.0424	0.8298	0.2815	0.0933	0.2692	0.1437	0.3312
US3	0.2536	-0.0317	0.8004	0.4813	0.4002	0.1858	-0.0328	0.2665
EU1	0.4482	0.1000	0.5384	0.3785	0.7458	0.2498	0.0041	0.1211
EU2	0.4490	0.0371	0.3664	0.3527	0.8121	0.2400	0.0973	0.1121
EU3	0.1979	0.2488	0.1456	0.6959	0.5290	0.3303	-0.1083	0.0686
AT1	0.4785	-0.0924	0.6157	0.7424	0.1542	0.0571	0.1806	0.2965
AT2	0.3715	-0.0861	0.4214	0.8585	0.3385	0.0310	0.3286	0.3112
AT3	0.2369	0.1093	0.3132	0.8720	0.2522	0.0275	0.1079	0.2698
SN1	0.6819	-0.0091	0.2597	0.3798	0.2530	0.5100	0.0819	-0.0036
SN2	0.2395	0.0398	0.2018	0.1389	0.3150	0.7992	0.0647	0.1321
SN3	0.3428	-0.0556	0.2666	0.0304	0.0880	0.7403	-0.0031	-0.1011
AC1	0.2356	0.0232	0.2311	0.3421	0.1123	-0.1223	0.2313	0.7832
AC2	0.1226	-0.2322	0.3111	0.3243	0.0656	-0.1123	0.3365	0.7215
AC3	0.2212	-0.0232	0.1132	0.2656	0.1223	-0.1363	0.3232	0.6812
IN1	0.9122	-0.0675	0.4408	0.2784	0.2025	0.2417	0.1282	0.1231
IN2	0.9133	-0.0412	0.3945	0.3175	0.2554	0.3772	0.0442	0.1132
IN4	0.8801	-0.1693	0.3197	0.2595	0.2139	0.1315	-0.0056	0.2139

Legend: ILn: incentive level. ITn: incentive type. MNn: monitoring. BEn: behavioral evaluation type.
RCn: repeated contracts. BIn: behavioral intention. RAn: risk aversion. SIn: self-interest.
VLn: voluntariness. USn: usefulness. EUn: ease of use. ATn: attitude.
SNn: subjective norm. ACn: acceptance (perceived). INn: infusion (perceived)
Note: The indicator pool was divided into two groups and factor analyzed separately
using the principal components approach with PROMAX rotation.

an artifact of the rotation method (Kim and Mueller 1978). Since several of the factors examined in this study were expected to correlated (e.g., usefulness and ease of use, incentive type and incentive level, perceived and actual infusion), oblique rotation was a safer technique. The factor loadings for each item obtained from EFA are summarized in Table 5.3, and the rotated factor structure is provided in Table 5.4.

As evident from Table 5.4, a simple factor structure emerged from exploratory factor analysis. A recommended criterion for assessing convergent validity is that each item should have a minimum factor loading of 0.6 on its hypothesized construct (SAS Institute Inc. 1990). Of a total of 46 items examined, this criterion was met for all but three items. Furthermore, after rotation, all items belonging to the same scale loaded on a common factor, thereby establishing convergent validity. Factor loadings ranged from 0.41 to 0.94, with several loadings exceeding 0.80. Comrey (1973) notes that loadings in excess of 0.45 can be considered fair, greater than 0.55 good, 0.63 very good, and 0.71 excellent. According to this categorization, 38 loadings in this study were in the "excellent" range, three in the "very good" range, and only five in the "fair" range.

Similarly, for discriminant validity, it has been suggested that items loading on a single factor should not have more than 0.3 loading on any other factor (SAS Institute Inc. 1990). The factor matrix in Table 5.4 indicates that this criterion was satisfied for 262 of 300 cross-factor loadings. No item loaded highly on more than one factor, further attesting to the discriminant validity of the scales. EFA results, therefore, provided overall support for the construct validity of the research instrument.

The factor structure obtained using EFA was then cross-validated using confirmatory factor analysis, conducted via the PLS technique (via the PLS-Graph program described later) using data from the experimental study. The hypothesized relationships between manifest variables (items) and latent variables (constructs) were captured in the a priori measurement model in PLS. Because the current study employed reflective indicators, estimation of factor loadings for the measurement model was based on simple bivariate regression and the resulting factors were free from multicollinearity. These loadings, along with corresponding EFA loadings and extracted variance, are presented in Table 5.3, while a sample PLS output is provided in Appendix E.

Table 5.3 indicates that factor loadings obtained from CFA were generally in accord with those obtained from EFA. In particular, 32 of 46 loadings improved from EFA to CFA, while the remaining 14 loadings decreased. Factor loadings obtained via CFA were expected to be more substantive since they utilized both theoretical expectations and empirical data. CFA also indicated that 11 of the 16 scales extracted 70 percent or more of the variance from their hypothesized indicators, while this figure was less than 50 percent for the risk aversion and rationality scales (see Table 5.3). However, being a pure variance-based approach, PLS did not provide any cross-construct loadings and therefore discriminant validity was not assessed[2].

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[2] Discriminant validity can however be assessed using covariance-based approaches such as LISREL.

5.4 Statistical Checks

This section analyzes the data from the experimental study in order to assess the demographics of the subject sample, to check for adequacy of treatment manipulation, and to examine the validity of assumptions of the intraorganizational IT usage model. Results from these analyses are presented next.

5.4.1 Sample Demographics

Demographic characteristics of the subject sample were computed using two SAS procedures: PROC FREQ for categorical variables (e.g., sex, major) and PROC MEANS for numeric variables (e.g., age, work experience). Results of these procedures are presented in Tables 5.5a and 5.5b. As indicated in these tables, the subject sample consisted of 53.1 percent males and 46.9 percent females. Of the 132 subjects in the experimental study, 33.1 percent were sophomores, 37.9 percent were juniors, 11.3 percent were seniors, 6.5 percent were post-bacculaureates, 5.6 percent were graduate students, and 5.6 percent belonged to other categories. Most subjects (22.3 percent) majored in accounting, followed by 19.8 percent in MIS, 15.7 percent in marketing, 14.9 percent in finance, 7.4 percent in management, and 19.8 percent in non-business disciplines. The age of the subject sample ranged from 18 to 57 years, with a mean of 23.6 years. The full-time work experience for 93 respondents ranged from 0 to 20 years, with a mean of 3.5 years. Prior to the experimental treatment, respondents had participated in an average of 1.8 budget allocation decisions at work (range: 0 to 25), used Excel 7.8 times (range: 0 to 50), and used SOLVER 1.17 times (range: 0 to 6 times).

Table 5.5a Sample demographics (categorical variables)

Variable	*# of obs.*	*Category*	*Frequency*	*Percent*
Sex	120	Male	64	53.1
		Female	56	46.9
Educational status	124	Sophomore	41	33.1
		Junior	47	37.9
		Senior	14	11.3
		Post-bacculeareate	8	6.5
		Graduate	7	5.6
		Other	7	5.6
Major	121	Accounting	27	22.3
		Finance	18	14.9
		Management	9	7.4
		Marketing	19	15.7
		MIS	24	19.8
		Other	24	19.8

Table 5.5b Sample demographics (numeric variables)

Variable	*# of obs.*	*Mean*	*Std. Dev.*	*Minimum*	*Maximum*
Age	122	23.56	7.875	17	57
Work exp. (full time)	93	3.46	4.844	0	20
Work exp. (part time)	105	3.03	2.335	0	12
Number of times participated in budget allocation tasks	113	1.75	5.445	0	25
Number of times Excel used	119	7.77	9.932	1	50
Number of times SOLVER used	119	1.17	1.542	1	7

5.4.2 Testing for Treatment Effects

Five PAM variables (i.e., incentive level, incentive type, monitoring, behavioral evaluation type, and repeated contract) were manipulated in this study via dichotomous treatments (e.g., high versus low). However, these variables were also measured perceptually using multiple-item, 7-point Likert scales. Dual measurement of these variables was intended to serve two purposes. First, the fit between objective treatment manipulations and subjects' perceptions of these manipulations would indicate the extent to which the treatments had the intended effect on subjects. Second, the perceptual measures could be used during subsequent model testing, since IT usage depends not on objective treatments but rather on subjects' perceptions of these treatments (Moore and Benbasat 1991).

Table 5.6 Validation of treatment effects using Spearman's correlation tests

Treatment variable	*Spearman's correlation*	*p-value ($\rho > 0$)*
Incentive level (IL)	0.4228	0.001
Incentive type (IT)	0.1948	0.032
Behavioral evaluation type (BE)	0.1438	0.114
Repeated contract (RC)	0.4212	0.001
Monitoring (MN)	0.2560	0.004

The fit between objective treatment manipulations and perceptual beliefs regarding these treatments was assessed using Spearman rank-order correlation analysis. Because objective treatments manipulations were binary in nature (e.g., high versus low, present versus absent) and corresponding perceptual items were measured on 7-point Likert scales (ranging from "strongly disagree" to "strongly agree"), difficulties in comparing the two scales ruled out the use of parametric methods such as Pearson's product-moment correlation. The perceptual items were thus aggregated and compared with the binary treatment using the non-parametric Spearman approach via PROC CORR in SAS with the

SPEARMAN option. Correlation between the actual and perceived treatment measures and the corresponding p-values (to test if the correlation statistic was significantly greater than zero) are reported in Table 5.6. This correlation was significant for four of the five manipulated variables (i.e., incentive level, incentive type, monitoring, and repeated contract) at 0.05 significance level, indicating that overall, these treatments were perceived by subjects as intended.

However, a somewhat poor fit was observed between objective and perceptual measures for the behavioral evaluation type treatment. Though this may pose a threat to internal validity regarding associations involving this variable, the severity of this threat is reduced by the fact that the behavioral evaluation type scale demonstrated a fairly high level of reliability (see Table 5.1). Nonetheless, given the above lack of fit, the effects of behavioral evaluation type must be treated with caution.

5.4.3 Validation of Model Assumptions

As discussed in Chapter III, the proposed principal-agent model of intraorganizational IT usage follows some assumptions, which may constrain the generalizability of the model to other contexts and populations. Three such assumptions tested in this study were rationality, self-interest, and voluntariness. The first two assumptions were derived directly from PAM, while the voluntariness assumption is taken from IT implementation research, which holds that IT usage must be voluntary in order to be considered a useful surrogate of implementation success (Lucas 1975).

These assumptions were tested using univariate t-tests by examining the extent to which aggregated measures of these variables (on a 1-7 scale) deviated from 4 (the mid-point on a 7-point Likert scale, representing "neither disagree - nor agree"). PROC UNIVARIATE in SAS was used to compute means, standard deviations, and sample sizes for each assumption, from which t-statistics were calculated using the formula $t = (\mu - \mu_0) / (s/\sqrt{n})$, where μ is the sample mean, μ_0 is equal to 4, s is the standard deviation of the sample data, and n is the number of observations. Results of the t-tests for the three model assumptions are presented in Table 5.7.

Table 5.7 Testing of model assumptions

Assumption	Num. of Obs.	Mean	Std. Dev.	t-statistic	p-value
Rationality	120	4.317	2.021	1.718	0.045
Self-interest	119	5.504	0.905	18.129	0.001
Voluntariness	122	4.725	2.019	3.966	0.001

As evident from the above table, all three model assumptions (i.e., rationality, self-interest, and voluntariness), were validated using data from the experimental study. Self-interest and voluntariness enjoyed the most support, having p-values less than 0.001. Rationality too was supported at 0.05 significance level; however, the t-test results may be difficult to interpret given the fact that the rationality scale consisted of three binary items, measuring three different axioms of rationality (e.g., transitivity, completeness). Note in this regard that prior research in experimental economics indicate only mixed support for the rationality axioms (see Kagel and Roth 1995), though the self-interest and voluntariness assumptions are generally supported by the political conflict (e.g., Markus 1983) and implementation (e.g., Lucas 1975) streams of MIS research respectively.

5.5 Model Testing

Partial least squares (PLS) analysis was used to test the proposed model of intraorganizational IT usage. Data for this analysis was collected from 132 subjects in the final experimental study (22 subjects per group for six treatment groups). Model validation was done by comparing the explanatory power of the TPB model in its traditional form (without PAM variables) with a new form of TPB that included the PAM variables (i.e., incentive and control).

PLS analysis was performed in this study using PLS-Graph (Chin and Frye 1994), a Microsoft Windows-based program which builds on the PLSX program developed by Lohmoller (1989). PLS-Graph employs a graphical user interface which allows for convenient specification of latent and manifest variables and linkages in a latent variable model. Empirical data is read from an ASCII data file and an iterative ordinary least squares method is used to compute path coefficients for hypothesized relationships and R^2 values (variance explained[3]) for all dependent variables in the specified model. Both the structural model (inner relations) and measurement model (outer relations) are estimated simultaneously from the same data set. The structural model can used for model testing

[3] Adjusted R^2 is a better measure of variance explained in the dependent variable because it accounts for the degrees of freedom (number of predictors) in the model. However, PLS-Graph does not provide any estimate of adjusted R^2, nor does it provide any listing of model sum of squares and error sum of squares, from where it can be calculated. Given this limitation, R^2 was used as a measure of variance explained.

and comparison, while the measurement model can be used for instrument validation (i.e., confirmatory factor analysis). The processing details are stored in a PLSX deck file and the output (e.g., factor structure, path coefficients, residual variance) is saved in an output file for future reference. Additionally, if any of the resampling options are used (e.g., bootstrapping or jackknifing) for estimating the significance of parameter estimates, the standard error and t-statistic values are stored in a separate output file.

In this study, two models were estimated using PLS-Graph: TPB (in its original form) and TPB augmented with PAM variables (see Figure 3.3). The purpose of this analysis was to isolate the proportion of variance in TPB that could be attributed to PAM variables. For each model, the dependent variable (intraorganizational IT usage) was assessed using four measures: actual acceptance, perceived acceptance, actual infusion and perceived infusion. Multiple-item, Likert-type, perceptual scales were used for measuring all other model variables (e.g., incentive type, attitude, perceived infusion).

PLS analysis of the PAM-augmented TPB model required a minimum sample size of 210 if all 42 indicators (corresponding to 15 scales) in the model were entered individually. Given that the sample size in this study (i.e., 132 observations) was less than 210, summated scales were used for each variable (the minimum sample size required for entering 15 summated scales in the model was 75). To compare the reasonableness of using summated scales, results obtained via the multiple-item scale and summated scales were used to estimate the original form of TPB model (since the TPB model employed 23 indicators corresponding to nine scales, a minimum of 115 observations were required for

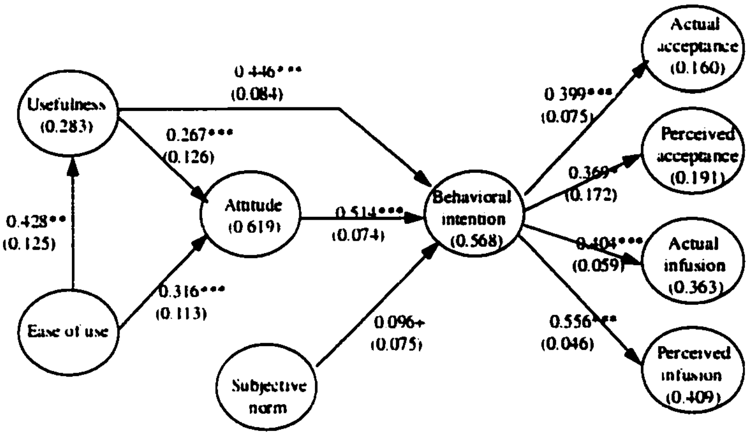

Figure 5.1 Theory of planned behavior (multiple-item scale approach)
Note: Numbers within parenthesis denote standard errors for path coefficients and R-square for constructs.
Significant paths are indicated by asterisk (+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

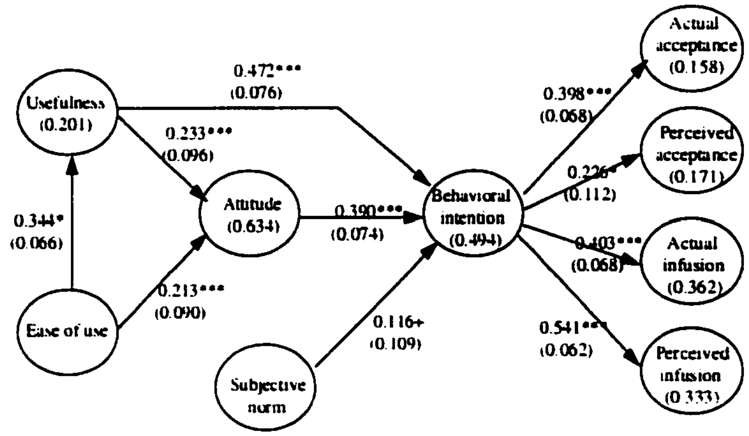

Figure 5.2 Theory of planned behavior (summated scale approach)
(+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

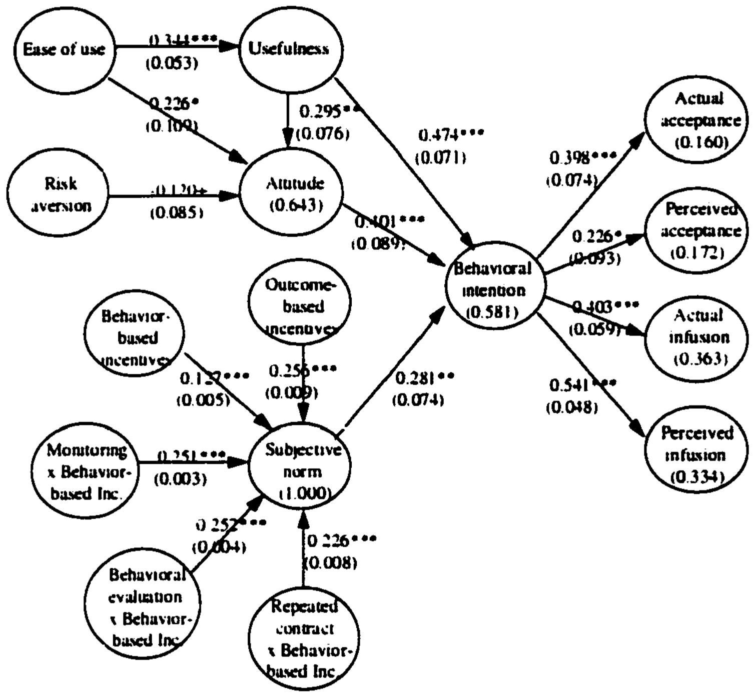

Figure 5.3 TPB augmented with PAM (summated scale approach)
(+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$)

the multiple-item scale approach, which was met in this study). Results of PLS estimation of TPB using multiple-item and summated scales are presented in Figures 5.1 and 5.2 respectively.

A comparison of Figures 5.1 and 5.2 shows that the path estimates, path significance, and variance explained in the multiple-item scale and summated scale versions of TPB are quite similar. The multiple-indicator version explained more variance in the all dependent variables except attitude. The overall significance of paths remained unchanged across the two models. For instance, the effect of subjective norm (defined in its traditional form) on behavioral intention to use IT was non-significant at 0.05 level in both models. The similarities across the two models suggests that using summated scales for estimating PAM-augmented TPB, as opposed to traditional multiple-item scales, is not a major threat to the results of the PLS analysis.

PLS estimation of the pure TPB and PAM-augmented TPB (using summated scales) are presented in Figures 5.2 and 5.3 respectively, while portions of the PLS-Graph output are listed in Appendix E. Included in each figure are path coefficients for hypothesized linkages, variance explained (assessed using R^2 values) for each dependent or endogenous variable, standard error of paths (assessed using the bootstrap resampling option), and significance of paths (indicated by asterisk).

An examination of TPB without PAM (Figure 5.2) indicates that with the exception of the path from subjective norm to behavioral intention, all path coefficients were significant at 0.05 level. In fact, several of the hypothesized associations were significant at 0.001 level (e.g., effect of intention on infusion). As expected, behavioral intention to use IT successfully predicted all four measures of usage (actual acceptance, perceived acceptance, actual infusion, and perceived infusion), though the path coefficient and proportion of variance explained were different across the four measures. While intention explained 16-17 percent of the variance on acceptance, it explained 33-36 percent of the variance on infusion variables. The R^2 values for infusion are roughly consistent with that reported in Sheppard, Hartwick, and Warshaw's (1988) meta-analysis of 87 studies, Davis, Bagozzi, and Warshaw (1989), and Taylor and Todd (1995). However, the R^2 values were considerably less for acceptance. This may be due to its operationalization as a binary variable, which does not capture as much of the variance in IT usage as a seven-level variable such as infusion in this study.

Attitude, usefulness, and subjective norm together explained 49 percent of the variance in behavioral intention; individual contributions of the three predictors being 30, 18, and 1 percent respectively (assessed by rerunning the same model in PLS after deleting the other links to the intention construct). The effects of attitude and usefulness on behavioral intention were significant at 0.05 level (note that the path from usefulness to intention was not theoretically justified but determined empirically by Davis, Bagozzi, and Warshaw 1989), while that of subjective norm (measured in its traditional form, as whether subjects felt that their instructor wanted them to utilize SOLVER) was found non-significant. This is in conformance with prior TAM-based research, which indicates weak or no support for subjective norm as a predictor of intention (e.g., Davis, Bagozzi, and Warshaw 1989, Mathieson 1991). Usefulness and ease of use were both significant predictors of attitude, together explaining 63 percent of the dependent variable

An examination of the TPB augmented with PAM variables (Figure 5.3) reveals that the effect of behavioral intention (inverse of goal incongruence) on the four measures of IT usage and the variance explained were virtually unchanged from the previous model (Figure 5.2). This was expected since intention and usage measures together formed a single block during PLS analysis (with no external effects), that remained unchanged across the two models. However, the proportion of behavioral intention explained increased from 0.49 in the pure-TPB model (Figure 5.2) to 0.58 in PAM-augmented TPB model (Figure 5.3). Since the paths from attitude and usefulness to intention were unchanged across the two models, the increase in explanatory power of the second model can be attributed to changing the subjective norm construct from its traditional operationalization (in Figure 5.2) to defining it in terms of incentive and control variables (in Figure 5.3). This is supported by the fact that the new subjective norm had significant effect on intention at 0.01 level, which was not the case with the earlier operationalization of the construct.

Associations between ease of use, usefulness, and attitude were found significant, as in the previous model, despite some minor variations in the magnitudes and relative effects of these variables. Risk aversion was added in the second model (TPB with PAM variables) as an additional predictor of attitude. As expected, risk aversion had a negative effect on attitude, however this effect was significant only at 0.10 level. Furthermore, addition of this variable increased the variance in attitude by less than 1 percent. The lack of an empirical association between risk aversion and attitude at the conventional significance level of 0.05 could be due to the operationalization of the risk aversion scale in terms of subjects' overall predisposition to risky situations in general, rather their risk attitude toward a specific behavior (e.g., IT usage). It has been suggested in the cognitive psychology literature that instruments that are not domain-specific tend to account for less variance in a particular behavior (Ajzen and Madden 1986). Rather than dismiss the relationship between risk aversion on attitude, it is therefore recommended that the effect between risk aversion and attitude be reexamined using risk aversion instruments tailored to the specific behavior under consideration.

The subjective norm construct in PAM-augmented TPB (Figure 5.3) was defined in terms of five effects: two main effects of outcome-based and behavior-based incentives and three interaction effects of behavior-based incentives with monitoring, behavioral evaluation type, and monitoring; and all five effects were significant. This was not surprising because subjective norm, defined completely and formatively in terms of these five effects, should be highly correlated with each of the five effects (which also explains why these variables explained 100 percent of the variance on the subjective norm construct). The path coefficients corresponding to the main effect of outcome-based incentives and the three interaction effects (involving behavior-based incentives and control variables) were similar in magnitude (ranging between 0.23 and 0.26), while the main effect of behavior-based incentives (0.13) was much less.

The findings from the analysis provide overall support for PAM's contention that incentives and control mechanisms are important predictors of IT usage. In addition, the link between behavior-based incentives and subjective norm can be strengthened if combined with control structures such as monitoring, behavioral evaluation type, or repeated contracts. Because the interaction effects of these control structures on subjective norm are similar, management's choice of control structures will depend on organizational and legal considerations such as costs of controlling, privacy issues, and so forth.

5.6 Summary

The purpose of this chapter was to test the principal-agent model (PAM) of intraorganizational IT usage derived in Chapter III using the laboratory experiment outlined in Chapter IV. A latent variable modeling (LVM) approach called partial least squares (PLS) was employed for this purpose. The explanatory power of PAM associations was isolated by analyzing and comparing two models: TPB (theory of planned behavior) in its traditional form (without PAM variables) and TPB enhanced with the incentive and control variables in PAM.

The chapter started with a discussion on the LVM approach, a comparison of two alternative ways of performing a LVM analysis (i.e., LISREL and PLS), and a description of the PLS technique and its relevance to the current problem. Results from two pilot studies and one experimental study were presented and discussed next. The first pilot was aimed at examining the overall feasibility of the research project and identifying potential improvements in experimental procedures, while the second pilot was directed at developing a psychometrically validated research instrument for subsequent use during the experimental study. Assessment of reliability and construct validity of each scale was conducted using a sequence of three statistical techniques: correlation analysis, exploratory factor analysis, and confirmatory factor analysis (using PLS), which can be viewed as a cumulative approach to instrument validation (Subramanian and Nilakanta 1994).

Three assumptions of PAM (i.e., rationality, self-interest, and voluntariness) were tested and validated using the experimental data. Treatment manipulations were checked using Spearman's rank correlational analysis between objective incentive/control treatments and their perceptual effects on subjects, and this fit was supported for four of five treatments. The lack of fit for behavioral evaluation type indicates that associations involving this variable must be treated with caution.

The proposed IT usage model was then tested using a PLS software package called PLS-Graph (Chin and Frye 1995). Two structural models were examined using

PLS: TPB without and with PAM. A comparison of results across the two models provided overall support that managerial incentives and control are indeed important predictors of IT usage within organizational settings. The effects of these variables can be incorporated into our current understanding of IT implementation/diffusion via the subjective norm construct in TPB. It was found that while individual attitude explains approximately 30 percent of the variance on behavioral intention to use IT, subjective norm (defined in terms of two main effects and three interaction effects of incentive and control variables) can explain an additional nine percent of the variance over and above TPB variables. Note that this definition of subjective norm is different from its traditional operationalization in the implementation literature, which did not have any significant effect on behavioral intention. Contrary to expectations, risk aversion had no significant effects on attitude; a possible reason for this lack of association is that the risk aversion scale employed in this study measured individual attitude toward risky situations in general rather than focusing on risk attitude specific to the IT usage context.

A comparison of the findings reported in this chapter with prior research in this area would help assess the explanatory power of the proposed model. This comparison, as well as implications of this research for MIS research and practice are presented in the concluding chapter of this dissertation.

Chapter VI

DISCUSSIONS AND CONCLUSIONS

The purpose of this research was to develop and test a theory-based model of intraorganizational IT usage that can not only advance our current understanding of IT usage by explaining the role of managerial incentives and control on organizational members' use of IT, but can also provide managers with normative guidelines for managing IT implementation/diffusion within their organizations more effectively. Principal-agent research in the microeconomics literature was employed as a theoretical foundation to model the relationship between managers and users regarding IT usage within organizations and then develop a principal-agent model (PAM) of intraorganizational IT usage by incorporating PAM concepts within a theory of planned behavior (TPB) framework (Ajzen 1985, 1991). Empirical data collected using a laboratory experiment provided overall support to the proposed model, and demonstrated that managerial influences, defined using TPB's subjective norm construct (a combination of PAM's incentive and control variables), can explain intraorganizational IT usage by about nine percent.

Chapter I of this dissertation presented a broad overview of the topic and mode of inquiry. Chapter II described our current state of knowledge in IT implementation/diffusion research and how this research could further knowledge building in this area. Chapter III developed a model of intraorganizational IT usage by incorporating PAM constructs within a TPB framework. Chapter IV described the laboratory experiment used to test the proposed model, including methodological issues such as variable operationalization, treatments, and task. The results of statistical testing of this model were presented and analyzed in Chapter V. The current and final chapter compares the study's findings with prior research in this area, and presents concluding remarks.

The remainder of the chapter proceeds as follows. The first section summarizes the major findings of this study. The second section compares the results obtained in this study with that from prior IT usage research. Potential implications of these findings for MIS researchers and practitioners are discussed in the third section. The fourth section identifies the theoretical and methodological limitations of this study. The final section suggests avenues for extending the research presented in this dissertation.

6.1 Summary of Major Findings

Partial least squares (PLS) analysis was used to model TPB in its traditional form (without PAM variables) and then augmented with PAM, in an effort to isolate the effects caused by PAM variables. Results of the analysis provided overall support for the causal linkages theoretically derived from PAM, while being generally consistent with prior implementation research. In both models, behavioral intention to use IT (inverse of goal incongruence in PAM) significantly predicted all four measures of IT usage (i.e., actual acceptance, perceived acceptance, actual infusion, and perceived infusion), accounting for 16-17 percent of the variance in acceptance, and 33-36 percent of the variance in infusion. This was expected since intention was the only determinant of IT usage in both models (TPB, without and with PAM). More substantive were the associations between intention and its determinants between the two models. While attitude explained 30 percent of the variance in intention, subjective norm in its traditional form (as defined in TPB) explained only one percent of the variance in intention. However, redefining subjective norm as a higher-order construct composed of beliefs related to managerial incentives and control led to an increase in variance explained in intention by about nine percent. This increase in explanatory power can be attributed to the role of managerial influences in organizational settings.

While usefulness and ease of use explained much of the variance in attitude, contrary to expectations, the addition of risk aversion did not contribute much to that explanation. Subjective norm was defined in this study as a formative collection of five incentive/control variables, that were hypothesized in PAM as affecting subjective norm via a process of managerial influence. Two main effects of outcome-based and behavior-based incentives and three interaction effects of behavior-based incentives with control structures such as monitoring, behavioral evaluation type, and repeated contracts on behavioral intention were tested, and all five effects were found significant.

Results of the current study therefore suggests that incentives and control structures can indeed be significant motivators of IT usage in organizational settings, and addition of these variables can help improve predict individual usage behavior by about nine percent over and above that explained by TAM variables (e.g., attitude, ease of use, and usefulness). A detailed analysis of these results was presented in Chapter V, and a comparison of these results with that from other studies in this area is described next.

6.2 Comparison with Prior Studies

Table 6.1 presents a comparison of the results in the current study with that of three prior TAM/TPB-based studies in the IT implementation literature (i.e., Davis, Bagozzi, and Warshaw 1989, Mathieson 1991, and Taylor and Todd 1995). Before contrasting these results, it is important to note two fundamental differences across these studies. First, different measures of usage were employed in these studies. For instance, Davis et al. (1989) utilized two items measuring frequency of use, Taylor and Todd (1995) used three items measuring the number of times IT was used, number of activities in which IT was used, and total usage time per session, while Mathieson (1991) did not examine usage but instead employed intention as a surrogate of use. In contrast, the current study measured appropriate use via two dimensions related to the breadth (acceptance) and depth (infusion) of usage. The second difference is related to the use of data analysis approaches; Davis et al. (1989) and Mathieson (1991) employed simple regression, Taylor and Todd (1995) used LISREL, while the current study employed PLS.

Table 6.1 Comparison of results (R^2) of current study with prior studies

Studies	*IT usage (actual)*	*IT usage (perceived)*	*Behavioral intention*	*Attitude*	*Subjective norm*
Davis et al. (1989)	-	0.40	0.51	0.36	ns
Mathieson (1991)	-	-	0.62	0.41	0.48
Taylor and Todd (1995)	-	0.36	0.60	0.76	0.57
Current study (1996)	0.16 (ac) 0.36 (in)	0.17 (ac) 0.33 (in)	0.58	0.66	1.00

Legend: ac: acceptance, in: infusion, ns: non-significant

As depicted in Table 6.1, the current study was one of the first to employ both actual and perceived measures of IT usage. Most prior research in this area have employed self-reported, perceptual measures of usage (e.g., Davis et al. 1989 and Taylor and Todd 1995), with very limited research utilizing objective measures to record usage (see Table 4.4 for a summary of usage operationalizations). Straub, Limayem, and Karhanna-Evaristo (1995) claimed that significant differences exist between self-reported use and actual use, and contended that perceptual measures should be avoided wherever possible because such usage can potentially be inflated (due to political or other considerations) or biased by cognitive limitations.

In this study, however, no significant differences were observed between actual and perceived measures of use. This may be attributed to two reasons. First, in the current experimental setting where subjects had to turn in the diskettes containing their work after task completion, many subjects believed that their usage could be determined by examining the diskettes and that incorrect usage reports may adversely affect the bonus points given for the task. This motivated them to report usage more accurately. Second, subjects' perception of usage was elicited in this study immediately following the task, so that subjects' self-reported use was less affected by cognitive biases and recall. However, the findings of this study do not refute Straub et al.'s (1995) claim regarding differences in between actual and perceived usage. It is possible that such differences may exist in actual organizational settings, where users' awareness of the unobservability of their usage behavior may induce them to report higher levels of use than actually expended.

An examination of perceived usage figures in Table 6.1 shows that variance explained by intention was 0.40 in Davis et al. (1989) and 0.36 in Taylor and Todd (1995). Variance explained in perceived infusion in the current study (0.33) is comparable to the above figures, but is significantly larger than that in perceived acceptance (0.17). Part of the poor explanatory capability of perceived acceptance can be attributed to its binary operationalization, which was unable to capture as much of the variance in usage as Likert scaled infusion measures.

Variance explained in behavioral intention to use IT as reported in this study (0.58) is similar to that obtained from prior studies (0.51 in Davis et al. 1989, 0.62 in Mathieson 1991 and 0.60 in Taylor and Todd 1995). It should however be noted that the Mathieson (1991) and Taylor and Todd (1995) studies included behavioral control as an additional predictor of intention, and therefore, might have captured more variance in intention than the current study. Rather than compare R^2 values for intention across these studies, of greater interest is how this variance is apportioned across the different determinants of intention (i.e., attitude and subjective norm).

Consistent with prior studies (e.g., Davis et al. 1989 and Mathieson 1991), attitude remained the most important predictor of behavioral intention, accounting for approximately 30 percent of the variance in the dependent variable, while subjective norm in its traditional form explained slightly over one percent of the variance. The inability of prior studies to validate the effect of subjective norm may be attributed to at least three reasons. First, these studies were conducted in personal-use settings where there were no real consequence associated with user behavior, and therefore, subjects had little external pressure to perform the intended behavior. It has been noted that in organizational settings where reward structures are often associated with individual behavior, subjective norm may have a greater impact on intention and usage (Fichman 1992, Taylor and Todd 1995), as was evident from the current study.

Second, Davis et al. (1989) and Mathieson (1991) treated subjective norm as a monolithic construct representing a weighted summation of all normative beliefs. In case two normative beliefs have opposite effects on subjective norm, combining them using a weighted summation will tend to cancel out their mutual effects, so that the resulting subjective norm may not accurately demonstrate the expected effects. Under such circumstances, examining the effect of each belief affecting subjective norm separately using LISREL or PLS may capture the individual effect of each determinant and of subjective norm better than would combining these beliefs as a monolithic construct.

Third, while the belief structures related to attitude have been developed, refined, and validated by Davis et al. (1989), little effort has been directed at identifying a stable set of beliefs related to subjective norm, leading to obscure and often inaccurate measures of this construct. The inability of traditional intention-based models in defining subjective norm has prompted the need for a broader exploration of the determinants of the construct beyond that held by the cognitive psychology literature (Taylor and Todd 1995).

The current study represents an initial attempt toward that goal by suggesting incentive and control variables as important determinants of subjective norm in organizational contexts. It is shown that by redefining subjective norm as a collection of beliefs related to incentive and control, explanation of behavioral intention can be increased by about nine percent. Also, by focusing on specific beliefs related to managerial influence, the proposed IT usage model becomes of greater practical use for managers interested in formulating strategies for effective IT implementation within their organizations.

The differential relative effects of attitude and subjective norm on user intentions in personal-use and organizational-use contexts can be understood in terms of voluntariness, if voluntariness is defined in terms of the nature of forces (i.e., internal or external) governing user motivation toward the intended behavior. A personal-use context (e.g., computer usage at home) can be characterized as "high voluntariness" setting, where individual behavior is motivated more by internal forces (i.e., beliefs and attitude toward the behavior) than by external forces (e.g., managerial or peer pressures) to conform to the behavior. Implementation research indicates that under such circumstances, attitude plays a greater role than subjective norm in explaining intentions and behavior (e.g., Taylor and Todd 1995). Conversely, an organizational setting can be described as a "low voluntariness" setting, where users are governed by external rather than internal forces, since they have little volition over their own behavior and are instead directed by supervisors/managers to behave in a certain way (Leonard-Barton 1987). It is reasonable to expect that in the latter setting, behavior will be directed more by subjective norm than by individual attitudes (Fichman 1992). In fact, Hartwick and Barki (1994) demonstrated that voluntary and mandated use results in differential relative impacts of attitude and subjective norm on IT usage. Therefore, though voluntariness does not have a direct effect on usage behavior, it plays a key role in identifying the behavioral context (i.e., personal-use versus organizational-use settings), which in turn would define the relative impacts of attitude and subjective norm on individual behavior.

The current study represented a less voluntary setting compared to the prior studies (e.g., Davis et al. 1989, Mathieson 1991, Taylor and Todd 1995), since subjects were provided with strong external forces to utilize SOLVER: subjects were told that SOLVER was the most efficient and error-proof way of solving the budget allocation task, and in addition, most subjects were given strong incentives (seven points) to utilize SOLVER. This may explain why subjective norm had a larger effect on behavioral intention in this study than in any of the prior studies. The voluntariness scale described here may therefore serve as an useful way to incorporate the role of behavioral contexts on individual behaviors.

6.3 Contributions of the Study

This section analyzes the potential contributions of this study to the academic and practitioner communities in MIS and is organized into two parts. The first part describes the implications of this study for MIS research, while the second part presents the implications for MIS practitioners.

6.3.1 Implications for MIS Research

The most important contribution of this study to MIS research is that it develops a theoretical model that can help explain why and how managerial actions influence individual use of IT within organizations, a linkage which has been missing in much of prior implementation/diffusion research. The proposed model postulates incentives and control as important components of managerial influence, which are shown to impact individual IT usage behavior via the subjective norm construct in TPB.

As discussed in Chapter II, current models of IT usage, such as TAM and innovation diffusion model, may work reasonably well in predicting IT usage in personal-use contexts, but their usefulness in organizational settings is limited because they fail to acknowledge the role of managerial influences on individual behavior (Fichman 1992). Managers can encourage or even mandate IT usage within organizations via expressed preferences and/or implicit reward structures (Leonard-Barton and Deschamps 1988). This relationship is accommodated in the current study by modeling the manager-user relationship in form of a principal-agent model. While the attitudinal component in TPB explains about 30 percent of the variance in intention to use IT, incentives and control variables in PAM, aggregated via the subjective norm construct, are found to explain an additional nine percent of intention over and above the attitudinal variables.

PAM serves to integrate micro-level individual factors (e.g., perceptual beliefs, attitude, and intention) with macro-level managerial factors (e.g., incentives and control) within a common framework, a goal that has been urged repeatedly in the implementation literature (DeSanctis 1984). Successful organizational implementation of IT requires not only positive beliefs, attitudes, and intentions on the part of users, but also appropriate incentives, strategies, and actions on the part of management. While prior usage models such as TAM and TPB are concerned only with individual-level attitudinal factors, PAM serves to integrate individual and managerial factors, in an effort to develop an holistic understanding of IT implementation.

A final contribution of this study is that it reestablishes the importance of incentives and self-interest in organizational thinking. In attempting to explain self-interested, albeit utility-maximizing, individual behavior within organizations characterized by goal incongruence, PAM provides a linkage between the traditionally segregated economic and political schools of thought in MIS research. The results of this study provides evidence that synergistic results may be obtained by combining ideas from cognitive psychology theories such as TPB and TAM with those from microeconomic theories such as PAM.

6.3.2 Implications for MIS Practitioners

Being a normative model, one of the strengths of the proposed principal-agent model of intraorganizational IT usage is its ability to prescribe guidelines that can be used by managers to enhance IT diffusion/implementation within their organizations. The common features of organizational incentive systems, as outlined by Baker, Jensen, and Murphy (1988) include: (1) egalitarian pay systems where compensation is largely independent of performance, (2) overwhelming use of promotion-based incentive systems, (3) absence of effective bonding contracts, and (4) general reluctance of employers to terminate, penalize, or give poor performance evaluations to employees. This study demonstrates that the effect of these incentive/control structures on the intended behavior do vary under different circumstances, and identifies conditions where one is more effective compared to the other.

Results of this study indicate that managers can proactively motivate IT usage behavior within organizations by offering higher levels of behavior-based incentives (e.g., hourly wage) or outcome-based incentives (e.g., commissions based on the output of IT usage) specifically linked to the appropriateness of IT use. However, behavior-based incentives may not have the same effect as outcome-based incentives due to potential user opportunism arising from the unobservability of user behavior. Control structures such as monitoring mechanisms (e.g., computer logs, supervisors), relative behavioral evaluation (e.g., promotion), and repeated contracts (where contract renewal is contingent on individual behavior) may be required under such circumstances, in conjunction with behavior-based incentives, in order to motivate IT usage. These are, in essence, answers to the three research questions presented in Chapter I of this dissertation.

Management's choice of control structures (e.g., monitoring, behavioral evaluation, or repeated contracts) may depend on a variety of considerations such as costs of creating and enforcing these structures, political climate within the organization, and so forth. An examination of these issues would focus on the management's decision problem in the management-user relationship, and was therefore beyond the scope of the current study.

6.4 Limitations of the Study

Being one of the earliest empirical studies investigating the effect of managerial incentives and control on intraorganizational IT usage, the current study suffers from several theoretical and methodological limitations. First, the proposed model was kept simple by assuming well-defined roles of managers and users as principals and agents respectively. In practice, however, these roles may be less clearly defined. In an organizational hierarchy, managers may be principals to IT users, but are themselves agents of company shareholders. Management goals may therefore be different from organizational (shareholder's) goals, and therefore managers may be less motivated to promote appropriate IT usage than would shareholders. Indeed, the relationship between shareholders and managers has attracted the most attention in principal-agent literature (e.g., Jensen and Meckling 1976), where shareholders often employ novel outcome-based incentives (e.g., executive compensation as a percentage of stock price or corporate profits) in order to coalign management goals with their own goals.

Second, for the most part, the principal-agent literature has depicted actors as self-interested, utility-maximizing individuals, with little regard for corporate goals and needs. This individualistic characterization of organizational members may capture incentive problems simply and starkly, but it avoids such issues as worker loyalty and corporate culture, which may be critical to an organization's success.

Third, much of the preceding discussion was based on positive incentives such as pay raises and promotions. Negative incentives such as punishments, threats, and dismissals can also have similar effects on agent behavior. Furthermore, the effect of negative incentives may be moderated by factors such as availability of alternative opportunities (state of nature). For example, though threats of termination can discipline users within organizations, the efficacy of the threat as a negative incentive decreases if the dismissed user can immediately find a new comparable job. The effects of negative incentives were however not examined in the current study because of operational and ethical considerations.

On the methodological front, several limitations can be identified in this study. First, laboratory experiments, by their very nature, tend to limit the external validity of results. Chapnis (1983) notes that such experiments can examine only a small number of independent variables, develop models that are at best rough and approximate models of reality, and produce results that may not be adequately generalized to other populations, settings, or treatments. However, because the ideas of incentives and control in the context of IT usage are new to most organizations, inadequate control over treatments is a severe limitation in conducting this study in field settings.

Second, limited manipulation of treatment variables in this study might have limited the usefulness of its results. For example, incentive type was operationalized dichotomously as behavior-based or outcome-based, while actual organizations may employ a combination of behavior-based and outcome-based incentives to motivate user behavior. In addition, organizations may employ a combination of incentives and control structures, as opposed to separable treatments as was done in this study, which would make isolation of effects more difficult.

Third, use of student settings, as employed in the current study, is generally subject to a few methodological biases. Awareness of the fact that students in more favorable treatment groups were rewarded more for the same or lesser work might have invited resentment from subjects in less favorable groups, leading to deliberate non-use and possible confounding of the hypothesized effects.

Fourth and finally, human cognitive biases may lead to self-generated validity in most questionnaire-based instruments (Kerlinger 1986). Survey respondents are likely to use answers to earlier questions in the research instrument as bases for responses to later questions, resulting in inflated psychometric properties (Taylor and Todd 1995). The factor analytic approach used to validate the different scales in this study fails to reflect this inflation in psychometric properties. Under these circumstances, multi-trait multi-method (MTMM) techniques, employing multiple means of collecting the same data (e.g., questionnaire, observation, and interview), may potentially be more useful is assessing the reliability and validity of research instruments.

6.5 Suggestions for Future Research

Future research in this area may take different forms. The IT usage model developed and tested in this dissertation was concerned only with the agent (user) side of the principal-agent problem. It examined what incentives and controls can effectively motivate user behavior and why, but ignored the management's problem (e.g., costs) in designing and implementing these incentives. However, a complete understanding of intraorganizational IT usage would require a thorough examination and synthesis of both perspectives. Since principal would prefer incentive structures that minimize his/her agency costs, specifying the problem in terms of agency costs and determining an optimal combination of incentive and control structures using a cost-minimizing approach may represent one way of extending the current research.

Second, to date, most applications of principal-agent research to the study of organizations have been restricted to theoretical exposition of propositions (e.g., Eisenhardt 1989, Gurbaxani and Kemerer 1990), rather than empirical testing of these propositions. Part of the difficulty encountered in testing these propositions is in developing operational measures and instruments for measuring abstract economic constructs such as risk aversion, information asymmetry, and rationality. Future studies may focus on developing appropriate measures and/or instruments for these constructs.

A third way of extending the current research is to replicate the study in field settings in order to improve the generalizability of its findings. The current study was restricted to a laboratory experiment because it emphasized causality over generalizability.

Future research may attempt to extend the laboratory results to more realistic organizational settings using the field survey approach.

Finally, the principal-agent model is a generic economic tool that can potentially be applied to a large number of MIS management problems characterized by goal conflict, risk aversion, and information asymmetry (Gurbaxani and Kemerer 1990). Future research efforts may be directed at identifying research problems that can potentially benefit from the use of this model.

Appendix A

RESEARCH INSTRUMENT

This assignment gives you an opportunity to earn between 2 and 7 points toward your grade in the class. It is also a part of a research project, details of which are available upon request. You are randomly assigned to one of six groups, and your grade in the assignment depends in part on your assigned group. To avoid confusion, please go over the following description of each group and make sure that you understand how you will be rewarded for participating in this assignment.

Group #	Explanation
0	You will receive 2 points for doing this assignment.
1	You will receive 2 points for doing this assignment, but if you utilize most of the functionalities of SOLVER appropriately, you can get a second extra-credit assignment similar to the current one, where you can get an additional 5 points.
2	You will receive between 2 and 7 points, depending on how well you <u>complete the assignment</u>, with or without using SOLVER.
3	You will receive between 2 and 7 points, however the bonus points depend not on your completion of the assignment, but rather on your <u>use of SOLVER</u> (the instructor will know exactly how you used SOLVER by examining your diskette).
4	You will receive between 2 and 7 points, depending on your <u>use of SOLVER</u> (and not on whether you can complete the assignment), however your use of SOLVER will be evaluated <u>relative</u> to other students in this group.
5	You can receive between 2 and 7 points for your <u>use of SOLVER</u>, however your activities on the computer is being <u>monitored</u> continuously on the network using a monitoring software package called SofTrack. Note that none of the other groups are being monitored because of the limitations associated with the trial version SofTrack.

For this assignment, you are required to do the following:

1. Read and sign the consent form.
2. Complete the pre-treatment questionnaire. Your responses in this questionnaire are solely for research purposes and will not affect your grade in this assignment or in the class in any way. This questionnaire consists of several statements, and you are required to indicate your opinions on each by checking on a scale from "extremely disagree" to "extremely agree." Note that checking on the middle of the scale will imply that you do not agree or disagree with the corresponding statement. Do not spend more than ten minutes on this questionnaire. Both the consent form and this questionnaire must be completed <u>before</u> you start working on the assignment. The proctor will collect it when you start working on the assignment.
3. You may now start working on your assignment. Note the time when you begin and end working on this assignment.
4. If you used Excel for doing the assignment (with or without SOLVER), please <u>save your work on diskette</u> with the filename EXTRACDT.XLS.
5. Finally, complete the post-treatment questionnaire. This should not take you more than five minutes.

If you have questions, comments, or concerns, please see the proctor.

Last SIX digits of your S.S.#: ____________ Group number (0-5): ________
Do not write your name anywhere on the questionnaire.

Pre-Treatment Questionnaire[1]

Please indicate your responses to the following questions. There are no right or wrong answers for any of these questions, the purpose of the questionnaire is merely to elicit your opinions regarding use of Excel SOLVER. Your responses are strictly confidential and will not affect your assignment grade or your grade in the class in any way.

DM1. Gender (circle one): Male / Female

DM2. Age. _____

DM3. Status: Sophomore / Junior / Senior / Post Baccalaureate / Graduate / Other: ____________

DM4. Expected major: Accounting / Finance / Management / Marketing / MIS / OM / Other: ____________

DM5. Full-time work experience: _____ years

DM6. Part-time work experience: _____ years

DM7. Approximate number of times you have used Excel prior to this assignment: ______ times

DM8. Number of times you have used Excel SOLVER prior to this assignment: ______ times

DM9. Number of times you have participated in budget allocation decisions at work: ______ times

DM10. Do you think that the assignment described in the tutorial is typical of a marketing manager?
disagree |______|______|______|______|______|______|______| agree
extremely quite slight neither slight quite extremely

Please read the following statements carefully and indicate whether you agree or disagree with each. Completing the questionnaire does not obligate you to use SOLVER in the assignment, and you are free to use or not use SOLVER in the actual assignment. Your responses in these statements will not hurt or benefit your grade on this assignment or in the class in any way, so please be honest.

*IL1. Compared to other students in the class, I will receive less bonus points for doing this assignment.
disagree |______|______|______|______|______|______|______| agree
extremely quite slight neither slight quite extremely

*IL2. Others in the class are being rewarded more than me for doing the same assignment.
disagree |______|______|______|______|______|______|______| agree
extremely quite slight neither slight quite extremely

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[1] Individual scale items are coded as follows: DM: demographic variables, IL: incentive level, IT: incentive type, MN: monitoring, BE: behavioral evaluation, RC: repeated contract, US: usefulness, EU: ease of use, AT: attitude, SN: Subjective norm, BI: Behavioral intention, RA: risk aversion, AC: acceptance, PF: performance, IN: infusion, VL: voluntariness, SI: self-interest, and RN: rationality. The suffix P to scale items indicate perceived measure and the suffix A indicate actual measure.
Items indicated by asterisk are reverse coded prior to analysis.
Items were randomly ordered in the final questionnaire administered to subjects.

*IL3. I think that I am receiving less reward than other students in the class for the same assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

IT1. The bonus points I will receive from this assignment depend not on my use of SOLVER, but rather on my completing this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

IT2. The bonus points I will receive from this assignment depend on my recommended solution in the assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

*IT3. The bonus points I will receive from this assignment are based on how well I use SOLVER, rather than on my completing this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

MN1. I believe that my computer use is being monitored.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

MN2. Some network software is monitoring my use or non-use of SOLVER.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

*MN3. I think that I am not being monitored.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

BE1. The bonus points I will receive in this assignment depend on how well I use SOLVER compared to others in my group.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

*BE2. The bonus points I receive from this assignment depends on my individual use of SOLVER, irrespective of others' use or non-use of SOLVER.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

BE3. My use of SOLVER in this assignment will be evaluated relative to others in my group.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

RC1. If I do well in the current assignment, I will receive have a second bonus assignment where I can earn five more extra-credit points.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

RC2. I can possibly get a second extra-credit assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

RC3. My performance in the current assignment will determine whether I can get a second extra-credit assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

US1. I think that using SOLVER will help me complete the assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

US2. In my opinion, SOLVER is a useful tool for doing assignments of this type.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

US3. I think that I will find SOLVER useful in completing this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

EU1. Using SOLVER will be easy for me.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

EU2. I can easily get SOLVER to do whatever I want it to do.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

*EU3. I think SOLVER is too complex to use.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

AT1. Using SOLVER is a ______ idea for this assignment.
bad I______I______I______I______I______I______I______I good
extremely quite slight neither slight quite extremely

AT2. I ____ the idea of using SOLVER for this assignment.
dislike I______I______I______I______I______I______I______I like
extremely quite slight neither slight quite extremely

*AT3. I think using SOLVER is a foolish idea for this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

SN1. I think I am expected to use SOLVER in this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

SN2. The instructor expects me to utilize SOLVER for completing this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

SN3. Though it was not mentioned, appropriate use of SOLVER is expected of me while doing this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

BI1. I intend using SOLVER for doing this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

BI2. Compared to other methods, I prefer using SOLVER for this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

BI3. I would rather use solver than any other methods in doing this assignment.

disagree I______I______I______I______I______I______I______I agree

extremely quite slight neither slight quite extremely

*RA1. Check the box that describes you best.

I avoid placing bets I______I______I______I______I______I______I______I I enjoy gambling for money

extremely quite slight neither slight quite extremely

*RA2. Mr. X is a journalist with substantial readership and a comfortable financial position. He takes pride in the integrity of his reporting and has achieved a modest reputation. Recently, he came up with a novel idea for writing a television drama. He would like to develop and promote this idea, but it would require him to quit his job and work full-time on this project. While the prospects of the project are uncertain, if he is successful, he will launch on a new and lucrative career. Imagine that you are advising Mr. X on whether or not he should embark into this project. List below are several probabilities or odds of his idea being successful. Check the <u>lowest probability</u> you would consider acceptable for Mr. X to quit his current job and try out a television career.

____ Check here if he should <u>not</u> quit his job even if the drama is highly likely to be successful.
____ The chances are 9 in 10 that the drama will be successful.
____ The chances are 7 in 10 that the drama will be successful.
____ The chances are 5 in 10 that the drama will be successful.
____ The chances are 3 in 10 that the drama will be successful.
____ The chances are 1 in 10 that the drama will be successful.
____ Check here if he should quit his job even if the drama is highly likely to be a failure.

*RA3. Check the box that represents the appeal of the following job to you (assume that you have the required skills and knowledge).

Commodity Trader: Studies supply and demand of basic commodities, such as wheat, soybeans, coffee, and silver, in order to buy and sell these for profit. Income depends on his ability to forecast successfully future price changes. Very large profits (or losses) are possible, however the risk too is large because of uncertain political, economic, and climactic events in different parts of the world.

unappealing I______I______I______I______I______I______I______I appealing

extremely quite slight neither slight quite extremely

RA4. Even if the possible returns are very large, I would hesitate putting any money into a business that could fail.

disagree I______I______I______I______I______I______I______I agree

extremely quite slight neither slight quite extremely

You may now begin working on the assignment.
After completing the assignment, be sure to complete the second questionnaire.

Last SIX digits of your S.S.#: ___________ Group number (0-5): ______
Do not write your name anywhere on this questionniare

Post-Treatment Questionnaire

Please indicate your responses to the following questions. There are no right or wrong answers for any of these questions, the purpose of the questionnaire is merely to elicit your opinions regarding use of Excel SOLVER. If you did not use SOLVER for the assignment, please indicate NA against the relevant questions and proceed. Not completing part of the questionnaire will not affect your grade on this assignment or in the class in any way.

*AC1. I used SOLVER for doing this assignment (circle one): Yes / No

*AC2. I tried using SOLVER, but could not get it to work, and therefore switched to a different method: Yes / No

AC3. The amount of time I spent using SOLVER is approximately: ______ minutes.

PF1. The total amount of time I spend on this assignment is approximately: ______ minutes.

PF2. I was able to complete the assignment.
disagree |______|______|______|______|______|______|______| agree
extremely quite slight neither slight quite extremely

PF3. I am confident that I obtained the correct results in this assignment.
disagree |______|______|______|______|______|______|______| agree
extremely quite slight neither slight quite extremely

PF4. Overall, I am satisfied with my performance in this assignment.
disagree |______|______|______|______|______|______|______| agree
extremely quite slight neither slight quite extremely

IN1. I made appropriate use of SOLVER in completing this assignment.
disagree |______|______|______|______|______|______|______| agree
extremely quite slight neither slight quite extremely

IN2. I used SOLVER correctly to do the assignment.
disagree |______|______|______|______|______|______|______| agree
extremely quite slight neither slight quite extremely

IN3. I used most of the functionalities of SOLVER in doing this assignment.
disagree |______|______|______|______|______|______|______| agree
extremely quite slight neither slight quite extremely

IN4. The steps I took while doing this assignment are (check as many as applicable):
[ ] Specifying values in the Set Target Cell box
[ ] Maximizing value in one target cell
[ ] Maximizing values in multiple target cells
[ ] Clicking the Reset All button
[ ] Minimizing values in multiple target cells
[ ] Setting up a range of cells that can be changed
[ ] Specifying which cells cannot be changed
[ ] Adding constraints
[ ] Setting integer constraints
[ ] Setting values in the Goal Seek box
[ ] Selecting the Best Estimate option
[ ] Using the Merge option in Scenario Manager

[ ] Using the Macro facility within SOLVER
[ ] Setting up Filters to be used
[ ] Setting up Tracer precedents and dependents

VL1. Though it was recommended, I was not required to use SOLVER for this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

VL2. I was free to use or not use SOLVER in this assignment.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

VL3. My decision regarding use of SOLVER in this assignment was entirely my own.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

SI1. I usually do things that are best for my own interests.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

SI2. Before I do anything, I examine if I can benefit from it in any way.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

SI3. Generally speaking, I consider my own interests before those of others.
disagree I______I______I______I______I______I______I______I agree
extremely quite slight neither slight quite extremely

RN1. Assume that you have entered a lottery organized by an used auto dealership, in which you will have one of three possible outcomes: (1) win a good car, (2) do not win anything, and (3) win a substandard car. Indicate your preferences below by circling true or false as appropriate.
You prefer winning a good car to not winning anything: True / False
You prefer not winning anything to winning a substandard car: True / False
You prefer winning a substandard car to winning a good car: True / False

RN2. Assume that you are faced with the following two lotteries:
Lottery X: You can receive a reward of either $100 or $10
Lottery Y: You can receive a reward of $50
You will always prefer lottery X over Y: True / False
You will always prefer lottery Y over X: True / False
Depending on the odds, you may be indifferent between X and Y: True / False

RN3. Assume that you are faced with the following two lotteries:
Lottery X: You can receive a reward of either $100 or $10
Lottery Y: You can receive a reward of either $50 or $10 (with the same odds as lottery X)
You will always prefer lottery X over Y: True / False
You will always prefer lottery Y over X: True / False
At certain times, you may be indifferent between lotteries X and Y: True / False

Please use the space below to provide any comments or concerns that you may have regarding the assignment.

Appendix B

EXPERIMENTAL AND TUTORIAL TASKS

Experimental Task: Solving a Budget Allocation Problem

Appliance Mart Superstore, headquartered in Boulder, Colorado, specializes in retailing household electrical appliances such as refrigerators, stoves, and washers. Most of their appliances are bought at wholesale prices from local manufacturers such as Goldstar Corp. Mike Jordan, the general manager of Appliance Mart, has hired you as his marketing manager for the Boulder outlet.

Mike has just received information from Goldstar about special dealer pricing on selected models of Goldstar refrigerators, stoves, and microwave ovens. Refrigerator Model 5601, which usually costs $935 wholesale, is now available at $850. The Gourmet Model S1200 stove, which usually costs $450 wholesale, is currently $420. And the popular Model 660 microwave oven, which usually costs $220 wholesale, is currently $195. This looks like a great opportunity to stock up on these fast moving merchandise and to increase profits.

Mike wants you to find out the most profitable mix of refrigerators, stoves, and microwaves that should be ordered to take advantage of the special Goldstar pricing. He tells you that you have a total budget of $50,000 for the order.

You figure out that you need profit margins on each of these three items since you are maximizing total profits for the entire order. You check with the sales manager John Smith, and he tells you retail selling prices for refrigerators, stoves, and microwaves are $1250, $595, and $250 respectively. You also learn that Appliance Mart has outstanding customer orders (back orders) for 6 refrigerators, 14 stoves, and 19 microwaves that are currently unavailable from their inventory, but must be delivered in a few days. The order that you recommend should meet these back orders.

Next, you call the warehouse manager and learn that the warehouse can accomodate 1,300 cubic feet of storage space for the entire order. Each refrigerator, stove, and microwave require 25, 18, and 3 cubic feet of storage space respectively.

Taking the above data into account, please provide your recommendations on the quantities of refrigerators, stoves, and microwave ovens to order, and the total profit expected out of this order. You are free to use or not use any computer hardware/software for performing this task. You can do any of the following (or any other method of your choice): (1) perform the calculations using a hand calculator and write down your recommendations on a piece of paper that you turn in, (2) use trial-and-error in Microsoft Excel, or (3) use the solver tool in Excel. The use of solver is suggested as one of the quickest, error-proof, and most productive ways of solving complex business problems of this type.

Tutorial Task: Solving Complex Business Problems Using SOLVER

Business owners or managers are often faced with complex business decisions such as amounts of goods to inventory or produce. In many instances, these decisions are based on intuition or gut feeling. In this tutorial, we will discuss one such typical business problem, and see how this problem can be solved effectively, faster, and with less errors using a Microsoft Excel tool called Solver.

PC Innovations specializes in retailing generic-brand microcomputer hardware such as desktop computers, laser printers, and monitors. Most of their goods are bought from local dealers such as Computer Discount Outlet at wholesale prices, and are sold later to retail consumers with a profit markup. Mike Jordan, the general manager of PC Innovations, just received information from Computer Discount Outlet about special promotional dealer pricing on selected models of their products. The popular Afga T300 laser printer which is normally bought at $375 is now available at $345, Amazing 486DX4/100 microcomputer which usually costs $755 is now available at $675, and Zeos 0.28 dpi SVGA color monitor which typically costs $173 is currently selling for $159. This looks like a great opportunity to stock up on these fast moving merchandise and reap increased profits.

However, Mike cannot quite figure out exactly how many laser printers, microcomputers, and monitors to buy to take advantage of the special promotional pricing. He has asked you, his marketing manager, the difficult task of finding out the most profitable mix of laser printers, microcomputers, and monitors that should be ordered. He tells you that you have a total budget of $15,000 for the entire order.

To start with, you figure out that you need profit margins on each of these three items since you wish to maximize total profits for the entire order. You check with the sales manager and learn that unit selling prices for laser printers, microcomputers, and monitors are $425, $799, and $199 respectively. The sales manager also tells you that PC Innovations have back orders of 3 laser printers, 10 microcomputers, and 7 monitors, that are currently unavailable in their inventory but must be delivered in three days. You have to order these minimum amounts, no matter how much it costs, in order to retain the company's goodwill with its customers.

You also remember that last time some merchandise was ordered, part of the order had to be returned because of lack of warehouse space. So you call the warehouse and learn that the products for the entire order must fit in 120 cubic feet of storage space and that each laser printer, microcomputer, and monitor require storage spaces of 5, 3, and 4 cubic feet respectively.

How many laser printers, microcomputers, and monitors should you order? There are several ways of obtaining a reasonable answer to this problem. For example, since microcomputers give you the most profit, you may try to squeeze in as many microcomputers you can within your budgetary and other constraints. When you cannot add an extra microcomputer, you can try to maximize the number of laser printers, and then monitors. This can be done by using trial and error (what-if analysis) in Excel or simply using a hand calculator. Alternatively, instead of trying to maximize the quantity of hardware that gives you the most per-unit profit, you may try to maximize the number of hardware that yield the highest profit-per-unit to storage-space ratio. Does this method produce this better solution compared to the earlier method? Is there a best possible solution to the given problem? Moreover, how do you know if a particular solution is good or bad? The answer to this question lies in total profits; the best solution is one that generates the most profit for the entire order, the worst answer is one that generated the smallest profits. However, if you used any of the above methods, you will not be sure whether the profits achieved is the highest possible. Microsoft Excel's Solver offers an quick, easy, and error-proof way of solving complex business problems of this type, which also guarantees the maximum profit.

In order to use Solver, you have to first set up the entire problem on a worksheet. You can figure out profits per laser printer, microcomputer, and monitor, and thereby total profts on the entire order. Next, invoke Solver from the Tools menu, and set the cell containing total order profit as the target cell to be maximixed. Specify cells that may be changed (i.e., cells containing the number of laser printers, microcomputers, and monitors to be ordered) to achieve maximum profits. Add constraints (i.e., budget constraint, space constraint, back order constraint) and click the Solve button. You will find that fractional quantities of laser printers, microcomputers, and monitors are recommended by Solver. To avoid this, you have to set up integer constraints, i.e., the cells containing the number of laser printers, microcomputers, and monitors to be ordered must contain integer values. The combination of laser printers, microcomputers, and monitors that obtained gives you the highest possible profit from this order.

Appendix C

SAMPLE SOFTRACK OUTPUT

```
Type of Report: Details of License use Report

File Server:    RICS_2
Requested by:   ANOL
Print Date:     April 24, 1996

Report Dates:   April 24, 1996 through April 24, 1996

User            Time In               Time Out              Network   Node
---------------------------------------------------------------------------------
License: [SOLVER]

R81IM95         12/ 4/95 at  4:04pm  12/ 4/95 at  4:30pm [        1][  AA00176357]
R56UO95         12/ 4/95 at  4:01pm  12/ 4/95 at  4:59pm [        1][  AA003F3C18]
R56UO95         12/ 4/95 at  4:01pm  12/ 4/95 at  4:34pm [        1][  AA003F3C18]
R54GM95         12/ 4/95 at  4:02pm  PURGED              [  address][ unavailable]
STDNT12         12/ 4/95 at  4:14pm  12/ 4/95 at  5:10pm [        8][0800093904D9]
R87AM95         12/ 4/95 at  4:05pm  12/ 4/95 at  4:40pm [       12][080009438838]
R56UO95         12/ 4/95 at  4:33pm  12/ 4/95 at  5:49pm [        1][  AA003F3C18]
R81OI95         12/ 4/95 at  4:17pm  12/ 4/95 at  6:03pm [        3][080009656482]
R82OO95         12/ 4/95 at  4:05pm  12/ 4/95 at  5:45pm [        3][080009655426]
R80IM95         12/ 4/95 at  4:01pm  12/ 4/95 at  4:50pm [        1][  AA00174DD4]
R54IQ95         12/ 4/95 at  4:09pm  12/ 4/95 at  4:51pm [        3][080009656EB6]
R89ES95         12/ 4/95 at  4:07pm  12/ 4/95 at  4:53pm [        8][  AA00589A2E]
R56MU95         12/ 4/95 at  4:03pm  12/ 4/95 at  5:54pm [        8][  AA0017504D]
R54GM95         12/ 4/95 at  4:02pm  12/ 4/95 at  5:14pm [        1][  AA00176356]
R58IA95         12/ 4/95 at  4:01pm  12/ 4/95 at  4:56pm [       12][0800093994DB]
R69OE95         12/ 4/95 at  4:05pm  12/ 4/95 at  5:58pm [        1][  AA00176356]
R69OE95         12/ 4/95 at  3:58pm  12/ 4/95 at  4:59pm [        1][  AA00176356]
R70QM95         12/ 4/95 at  4:51pm  12/ 4/95 at  6:02pm [        3][080009656EB4]
R58UO95         12/ 4/95 at  4:12pm  12/ 4/95 at  5:08pm [        1][  AA00174EB1]
R98QE95         12/ 4/95 at  4:08pm  12/ 4/95 at  4:58pm [        8][  AA00174A9E]
In Use Time: 0 days 17:03, Maximum In Use For License SOLVER [19]
```

Appendix D

PARTICIPANT CONSENT FORM

You are requested to read the following information and indicate your consent to participating in this research project by signing where indicated.

> I, ______________________ (write your name), agree to participate in this research project, conducted by Anol Bhattacherjee of the University of Houston, which examines human behavior regarding use of computer software. I am told that the scope and purpose of the project can be made available on request on completion of the session. I understand that I will receive bonus points towards my final grade in the class for participating in the project, and that non-participation will not affect my grade in any way.
>
> I understand that I will be asked to complete an optional, extra-credit assignment in Microsoft Excel, and fill out two questionnaires, intended to elicit my beliefs about using Excel SOLVER. I am told that the task may take between one and one-and-half hours to complete, and that the two questionnaires will take approximately ten and five minutes each. I understand that my responses in the questionnaire will be used purely for research, are entirely voluntary, and have no bearing on my grade in the assignment or in the class in any way. I also understand that my identity will remain confidential, and that information from the project will be reported only in the aggregate, and that no individual data will be disclosed or published.
>
> The principal researcher has informed me that no personal risk or discomfort is expected from my participation in this project. I have been invited to call Anol Bhattacherjee at (713) 743-4735 or Dr. Richard Scamell at (713) 743-4733, if I have questions about the project or its results.
>
> Finally I understand that I may withdraw my consent and discontinue participation in this project at any time without penalty or loss of benefits.

SIGNED: ___________________________

DATED ______________

THIS PROJECT HAS BEEN REVIEWED BY THE UNIVERSITY OF HOUSTON COMMITTEE FOR THE PROTECTION OF HUMAN SUBJECTS (PHONE 743-9222).

Appendix E

SAMPLE PLS-GRAPH OUTPUT

Testing Measurement Model (Confirmatory Factor Analysis)

```
Number of Blocks        NBLOCS =   15
Number of Cases         NCASES =  132
Number of Dimensions      NDIM =    1
Number of Iterations     NITER =  100

Convergence at Iteration Cycle No.  12
```

Block	N-MV	Deflate	LV-Mode	Model
ACA	1	yes	outward	Exogen
ACP	3	yes	outward	Exogen
INA	1	yes	outward	Exogen
INP	3	yes	outward	Exogen
BI	3	yes	outward	Exogen
SN	3	yes	outward	Exogen
AT	3	yes	outward	Exogen
US	3	yes	outward	Exogen
EU	3	yes	outward	Exogen
RA	4	yes	outward	Exogen
IL	3	yes	outward	Exogen
IT	3	yes	outward	Exogen
MN	3	yes	outward	Exogen
BE	3	yes	outward	Exogen
RC	3	yes	outward	Exogen
RN	4	yes	inward	Exogen
SI	3	yes	outward	Exogen
VL	3	yes	outward	Exogen

Outer Model

	Variable	Weight	Loading	Location	ResidVar	Communal	Redundan
BI	bi1	0.3943	0.9148	0.0000	0.1632	0.8368	0.4848
	bi2	0.3639	0.9446	0.0000	0.1077	0.8923	0.5170
	bi3	0.3300	0.8957	0.0000	0.1977	0.8023	0.4648
ACA	aca	1.0000	1.0000	0.0000	0.0000	1.0000	0.1597
ACP	ac1	-0.5579	-0.8513	0.0000	0.2753	0.7247	0.1261
	ac2	-0.6229	-0.8599	0.0000	0.2606	0.7394	0.1287
	ac3	-0.3566	-0.8665	0.0000	0.2363	0.7123	0.1232
IL	il1	-0.4242	-0.9349	0.0000	0.1260	0.8740	0.0000
	il2	-0.3233	-0.9156	0.0000	0.1617	0.8383	0.0000
	il3	-0.3355	-0.9165	0.0000	0.1601	0.8399	0.0000
IT	it1	0.4179	0.8138	0.0000	0.3377	0.6623	0.0897
	it2	0.5916	0.8031	0.0000	0.3551	0.6449	0.0874
	it3	-0.2970	-0.6220	0.0000	0.6131	0.3869	0.0524
MN	mn1	0.4091	0.9237	0.0000	0.1469	0.8531	0.0000
	mn2	0.3399	0.8658	0.0000	0.2503	0.7497	0.0000
	mn3	-0.3615	-0.9069	0.0000	0.1775	0.8225	0.0000
BE	be1	-0.3958	-0.7869	0.0000	0.3807	0.6193	0.0000
	be2	0.4518	0.7446	0.0000	0.4452	0.5548	0.0000
	be3	-0.4253	-0.8276	0.0000	0.3150	0.6850	0.0000
RC	rc1	-0.1231	-0.8893	0.0000	0.2091	0.7909	0.0000
	rc2	-0.4085	-0.9130	0.0000	0.1665	0.8335	0.0000
	rc3	-0.5497	-0.9416	0.0000	0.1133	0.8867	0.0000
AT	at1	0.4243	0.9144	0.0000	0.1640	0.8360	0.3098
	at2	0.4085	0.9129	0.0000	0.1667	0.8333	0.3088
	at3	-0.3082	-0.7758	0.0000	0.3981	0.6019	0.2231
US	us1	0.3808	0.8845	0.0000	0.2176	0.7824	0.0000
	us2	0.3378	0.8791	0.0000	0.2271	0.7729	0.0000
	us3	0.3965	0.9254	0.0000	0.1435	0.8565	0.0000
EU	eu1	0.4039	0.8785	0.0000	0.2283	0.7717	0.0000
	eu2	0.3770	0.8638	0.0000	0.2538	0.7462	0.0000
	eu3	-0.4209	-0.7592	0.0000	0.4237	0.5763	0.0000
RA	ra1	0.3748	0.6241	0.0000	0.6105	0.3895	0.0000
	ra2	0.3061	0.5522	0.0000	0.6951	0.3049	0.0000
	ra3	0.6869	0.8738	0.0000	0.2364	0.7636	0.0000
	ra4	0.0054	-0.3435	0.0000	0.8820	0.1180	0.0000
INA	ina	1.0000	1.0000	0.0000	0.0000	1.0000	0.1634
INP	in1	0.3394	0.9222	0.0000	0.1496	0.8504	0.2845
	in2	0.3354	0.9188	0.0000	0.1557	0.8443	0.2824
	in3	0.2368	0.5900	0.0000	0.2079	0.3521	0.1150
	in4	0.2847	0.8974	0.0000	0.6431	0.6569	0.2694
SN	sn1	0.3727	0.8120	0.0000	0.3407	0.6593	0.1317
	sn2	0.2906	0.6570	0.0000	0.5683	0.4317	0.0862
	sn3	0.5742	0.8820	0.0000	0.2222	0.7778	0.1553

Testing Structural Model: TPB with PAM Variables
(Using Bootstrap Resampling Option with Construct Level Sign Changes)

Path Coefficients Table (Entire Sample Estimate):

	ACA	ACP	INA	INP	BI	SN-IC	AT	US	EU	RA	OUT	BEH	MN*BEH	BE*BEH	RC*BEH
ACA	0.000	0.000	0.000	0.000	0.398	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ACP	0.000	0.000	0.000	0.000	0.226	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INA	0.000	0.000	0.000	0.000	0.403	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INP	0.000	0.000	0.000	0.000	0.541	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BI	0.000	0.000	0.000	0.000	0.000	0.281	0.401	0.474	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SN-IC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.256	0.127	0.251	0.252	0.226
AT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.295	0.226	-0.120	0.000	0.000	0.000	0.000	0.000
US	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.344	0.000	0.000	0.000	0.000	0.000	0.000
EU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OUT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MN*BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BE*BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RC*BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Path Coefficients Table (Standard Error):

	ACA	ACP	INA	INP	BI	SN-IC	AT	US	EU	RA	OUT	BEH	MN*BEH	BE*BEH	RC*BEH
ACA	0.000	0.000	0.000	0.000	0.074	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ACP	0.000	0.000	0.000	0.000	0.093	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INA	0.000	0.000	0.000	0.000	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INP	0.000	0.000	0.000	0.000	0.048	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BI	0.000	0.000	0.000	0.000	0.000	0.074	0.089	0.071	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SN-IC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.009	0.005	0.003	0.004	0.008
AT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.076	0.109	0.085	0.000	0.000	0.000	0.000	0.000
US	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.053	0.000	0.000	0.000	0.000	0.000	0.000
EU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OUT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MN*BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BE*BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RC*BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Path Coefficients Table (T-Statistic):

	ACA	ACP	INA	INP	BI	SN-IC	AT	US	EU	RA	OUT	BEH	MN*BEH	BE*BEH	RC*BEH
ACA	0.000	0.000	0.000	0.000	5.347	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
ACP	0.000	0.000	0.000	0.000	1.739	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INA	0.000	0.000	0.000	0.000	6.887	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
INP	0.000	0.000	0.000	0.000	11.273	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BI	0.000	0.000	0.000	0.000	0.000	2.093	4.484	6.655	0.000	0.000	0.000	0.000	0.000	0.000	0.000
SN-IC	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	14.986	56.885	75.861	60.376	28.169
AT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.8519	2.084	1.172	0.000	0.000	0.000	0.000	0.000
US	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.522	0.000	0.000	0.000	0.000	0.000	0.000
EU	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RA	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
OUT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
MN*BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
BE*BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
RC*BEH	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Correlations of latent variables:

	ACA	ACP	INA	INP	BI	SN-IC	AT	US	EU	RA	OUT	BEH	MN*BEH	BE*BEH	RC*BEH
ACA	1.000														
ACP	0.094	1.000													
INA	0.821	0.534	1.000												
INP	0.620	0.332	0.705	1.000											
BI	0.498	0.526	0.403	0.541	1.000										
SN-IC	0.126	0.054	0.042	0.093	-0.037	1.000									
AT	0.368	0.199	0.415	0.322	0.538	0.093	1.000								
US	0.270	0.227	0.315	0.357	0.595	0.013	0.306	1.000							
EU	0.260	0.056	0.325	0.304	0.272	-0.103	0.293	0.344	1.000						
RA	0.017	0.001	-0.006	-0.009	0.075	-0.022	0.189	0.065	-0.040	1.000					
OUT	0.128	0.243	0.162	0.124	-0.092	0.487	0.015	0.006	-0.168	-0.086	1.000				
BEH	0.126	0.018	0.038	0.080	-0.056	0.985	0.091	-0.009	-0.098	-0.035	0.299	1.000			
MN*BEH	0.122	0.038	0.015	0.047	-0.041	0.969	0.080	0.009	-0.105	-0.045	0.370	0.976	1.000		
BE*BEH	0.121	0.025	0.022	0.051	-0.085	0.971	0.047	-0.010	-0.083	-0.033	0.309	0.968	0.958	1.000	
RC*BEH	0.071	0.011	0.009	0.141	0.089	0.875	0.160	0.066	-0.043	0.078	0.473	0.840	0.795	0.792	1.000

International political economic factors played a greater role in the adoption of environmental technologies in the six Southeast Asian bleached kraft mills than they did in the KCA/Apcel case. Business and social movement factors also contributed to these technologies' adoption in Southeast Asia.

The technologies was developed in Sweden and Finland, in response to European social movements' efforts to tighten environmental regulations and increase demand for 'green' products. Not only are they 'cleaner' technologies, but they also use raw materials and chemicals more efficiently.

When these technologies were coming on the market (in the late 1980s and early 1990s), Finland and Sweden were undergoing their worst economic (and political) crises in over 60 years, and Europe and North America were in the midst of a major economic slump.[100] The Asia-Pacific region was one of the few areas of the world expanding rapidly at the time. Technology supply firms and Nordic governments gave Asia-Pacific pulp producers excellent financial incentives for adopting the new technologies, in the form of price discounts, trade credits, interest-free loans, even joint venture capital.

Southeast Asian pulp firms adopted the new technologies also to boost their image, secure regulatory support for continued and expanded operations, guaranteed access to 'green' export markets, and help obtain financing on international capital markets. Southeast Asian social movements helped ensure adoption of advanced post-process, as well as process, technologies by keeping pressure on local manufacturers and regulatory agencies.

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[100]See Chapter 7, "Finland & Sweden: Vikings and Tigers."

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