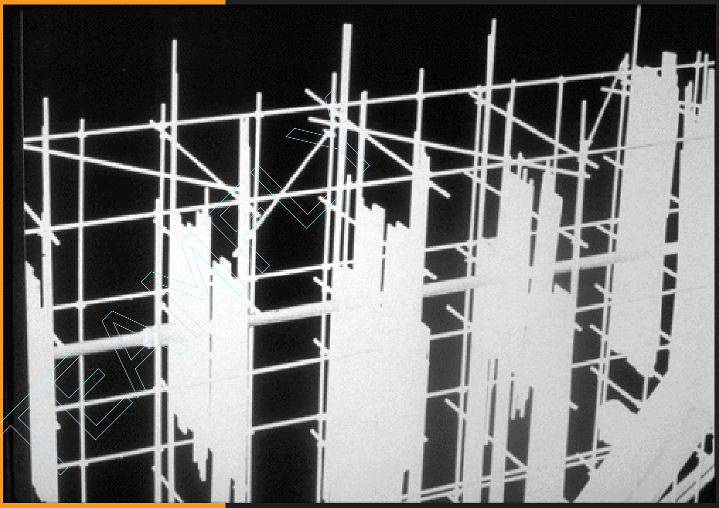
Advanced Topics in Information Resources Management



Mehdi Khosrowpour

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Advanced Topics in Information Resources Management

Table of Contents

Preface

The field of information resources management is broad and encompasses many facets of information technology research and practice as well as business and organizational processes. Because information technology changes at an incredible rate, it is essential for all who use, teach or research information management to have access to the most current data and research and keep up with the emerging trends. This publication is the first volume (Vol. I-1) of the new Series on "Advanced Topics in Information Resources Management" that is aimed to provide a greater understanding of issues, challenges, trends, and technologies effecting the overall utilization and management of information technology in modern organizations around the world.

The chapters in this book address the emerging issues in information resources management and its application. Knowledge management, business process change, achieving and maintaining competitive advantage with information technology and systems are topics relevant to business people and academics. Additionally, the chapters provide concrete ways for academics to broaden their research and case study examples, which will enable business people to avoid the pitfalls discussed in the book

Chapter 1 entitled, "Knowledge management and New Organization Forms: A Framework for Business Model Innovation" by Yogesh Malhotra of @Brint.com (USA) proposes a conceptualization in the form of a framework for developing knowledge management systems for business model innovation. This framework will facilitate the development of new business models that are better suited to the new business environment, which is characterized by a dynamic, discontinuous and radical pace of change. The chapter further discusses how the application of this framework can facilitate development of new business models.

Chapter 2 entitled, "Using a Metadata Framework to Improve Data Resources Quality" by Tor Guimaraes, Tennessee Technological University, Youngohc Yoon of University of Maryland Baltimore County and Peter Aiken, Defense Information Systems Agency (USA) presents a metadata framework as a critical tool to ensure data quality. The model presented enables further development of life cycle phase-specific data quality engineering methods. The chapter expands the concept of applicable data quality dimensions and presents data quality as a function of four distinct components: data value quality, data representation quality, data model quality, and data architecture quality. The chapter then discusses each of these components.

Chapter 3 entitled, "Visualizing IT Enabled Business Process Change (BPC)" by Martijn Hoogeweegen of Erasmus College (Netherlands) focuses on supporting BPC mangers in their search for information technology (IT) enabled alternative process designs. The authors provide a literature review to formulate a number of IT enabled NBPC guidelines. They then visualize these guidelines in process charts. Finally, the chapter discusses a case study to illustrate the applicability of these guidelines.

Chapter 4 entitled, "Relating IS Infrastructure to Core Competencies and Competitive Advantage" by Terry A. Byrd of Auburn University (USA) presents and describes a model that illustrates the possible connection between competitive advantage and IT. Furthermore, the chapter shows how one major component of the overall IT resources, the information systems infrastructure might yield sustained competitive advantage for an organization. By showing that information systems infrastructure flexibility acts as an enabler of the core competencies, the author demonstrates the relationship to sustained competitive advantage.

Chapter 5 entitled, "Theoretical Justification for IT Infrastructure Investments" by Timothy Kayworth of Baylor University, Debabroto Chatterjee of Washington State University and V. Sambamurthy of University of Maryland (USA) proposes a theoretical framework to justify the value creating potential of IT infrastructure investments. The chapter presents a conceptual framework that describes the nature of IT infrastructure and its related components. Next, the authors discuss the role of IT infrastructure as a competitive weapon and identify three areas where IT may create strategic value and discuss specific theories and research propositions to guide further infrastructure research.

Chapter 6 entitled, "Technology Acceptance and Performance: In Investigation into Requisite Knowledge" by Thomas Marshall, Terry Byrd, Lorraine Gardner and R. Kelly Rainer of Auburn University (USA) investigates how knowledge bases contribute to subjects' attitudes and performance in the use of Computer Aided Software Engineering (CASE) tool database design. The study discussed in the chapter identified requisite knowledge bases and knowledge base interactions that significantly impacted subjects' attitudes and performance. Based on the findings, the authors present alternatives that may help organizations increase the benefits of technology use and promote positive attitudes towards technology innovation acceptance and adoption.

Chapter 7 entitled, "Motivations and Perceptions Related to the Acceptance of Convergent Media Delivered Through the World Wide Web" by Thomas Stafford and Marla Royne Stafford of University of Memphis and Neal G. Shaw of University of Texas-Arlington (USA) examines the well-understood technology adoption precepts of the Technology Acceptance Model in conjunction with the media-use motivations theories arising from the adaptations of the Uses and Gratifications perspective, with special emphasis on the emerging effects of social gratifications for Internet use.

Chapter 8 entitled, "Key Issues in IS Management in Norway: An Empirical Study

Based on Q Methodology" by Petter Gottschalk of the Norwegian School of Management (Norway) provides an overview of research approaches to key issues studies combined with key issue results from previous research. The paper introduces a three-step procedure for key issues selection and the author adopts a Q-sort analysis. The chapter presents results from the Q-sort survey and analysis. The most important issue as reported by the study is improving the links between information systems strategy and business strategy.

Chapter 9 entitled, "Managing Strategic IT Investment Decisions From IT Investment Intensity To Effectiveness" by Tzu-Chuan Chou and Robert G. Dyson of the University of Warwick and Phillip L. Powell of University of Bath (UK) proposes an analytical model employing a number of constructs, namely: effectiveness of decisions, interaction and involvement in decision formulation process, accuracy of information and strategic considerations in the evaluation process, accuracy of information and strategic considerations in the evaluation process, rarity of decisions, and the degree of IT intensity of an investment in strategic investment decisions. The results show that interaction, accuracy of information and strategic considerations are the mediators in linking of IT investment intensity and effectiveness.

Chapter 10 entitled, "Extending the Technology Acceptance Model Beyond its Country of Origin: A Cultural Test in Western Europe" by Said Al-Gahtani of King Khalid University (Saudi Arabia) reports on a study that attempted to theoretically and empirically test the applicability of the technology acceptance model (TAM) in the culture of Western Europe. The chapter begins by discussing the background of spreadsheets and the role they played in the diffusion computer technology and into organizations and then presents the results of the study.

Chapter 11 entitled, "The Collaborative Use of Information Technology: End-User Participation and Systems Success" by William J. Doll of the University of Toledo and Xiaodon Deng of Oakland University (USA) presents a congruence construct of participation that measures whether end users participate as much as they would like to in key systems analysis decisions. The results indicate that user participation is best achieved in collaborative applications. The findings of this chapter will help managers and analysts make better decisions about how to focus efforts to increase participation and whether end-users should participate as much as they want to.

Chapter 12 entitled, "User Satisfaction with EDI: An Empirical Investigation" by Mary Jones of Mississippi State University and Robert Betty of Texas Christian University (USA) identifies results of a study undertaken to identify antecedents of end-user satisfaction by surveying key end users of EDI from a variety of organizations across the United States. The results of the study indicate that the greater the perceived benefits of EDI, the grater the user satisfaction. A second results shows that the more compatible EDI is with existing organizational practices and systems, the more satisfied the users are with them.

Chapter 13 entitled, "Corporate Intranet Infusion" by Lauren Eder and Marvin Darter of Rider University (USA) examines organizational, contextual and technical variables that are associated with intranet infusion in the United States. The authors analyzed six independent variables using an ordered probit analysis to explain the likelihood of the occurrence for different levels of intranet infusion. The results indicate that top management support, IT infrastructure and competition positively influence high levels of intranet infusion. Organizational size is negatively associated with levels of intranet infusion.

Chapter 14 entitled, "Dynamics of Information in Disseminating Academic Research in the New Media: A Case Study" by James Ho of University of Illinois at Chicago presents the history of a case in point with data recorded over a period of fifteen months. The results of the case study indicate that the Internet in general and the World Wide Web in specific will be a significant resource in bridging the gap between practice and relevant research. The author reports on a successful experience in an experiment to disseminate research results in the New Media. The article concludes that if professors are willing to broaden their customer base, there is an expanding network of practitioners to tap their expertise and provide feedback for their academic research.

Chapter 15 entitled, "Assessing the Value of Information Technology Investment to Firm Performance" by Qing Hu of Florida Atlantic University and Robert Plant of the University of Miami (USA) argues that the causal relationship between IT investment and firm performance an not be reliably established through concurrent IT and performance data. The authors speculate that inferring the causality of IT investments in the years preceding are significantly correlated with the performance of the firm in subsequent years may not be the most accurate. Rather, they discuss a model, which indicates that improved financial performance over consecutive years may contribute to the increase of IT investment in subsequent years.

Chapter 16 entitled, "Some Evidence on the Detection of Data Errors" by Barbara Klein of University of Michigan—Dearborn (USA) reports the results of a study showing that municipal bond analysts detect data errors the results provide insights into the conditions under which users in organizational settings detect data errors and discusses guidelines for improving error detection. The results of the study indicate the users of information systems can be successful in detecting errors.

Chapter 17 entitled, "An Analysis of Academic Research Productivity of Information Systems Faculty" by Qing Hu of Florida Atlantic University and T. Grandon Gill of University of South Florida (USA) discusses the results of a study inquiring about faculty research productivity. The results show that while there are only two significant factors contributing positively to research productivity: time allocated to research and the existence of a doctoral program, many other factors appear to adversely affect research productivity. The results also suggest that some of the commonly held motivations for research such as tenure or academic rate have no effect at all.

Chapter 18 entitled, "Integrating Knowledge Process and System Design for Naval Battle Groups" by Mark Nissen and Elias Oxedine IV of the Naval Postgraduate School (USA) integrates a framework for knowledge process and system design that covers the gamut of design considerations from the enterprise process in the large, through alternative classes of knowledge in the middle and onto specific systems in detail. Using the methodology suggested in the chapter, the reader can see how to identify, select, compose and integrate the many component applications and technologies required for effective knowledge system and process design.

Chapter 19 entitled, "A Case Study of Project Champion Departure in Expert Systems Development" by Janice Sipior of Villanova University (USA) discusses an expert systems project by examining the experiences of Cib-Geigy corporation with an expert systems project which was impeded by the departure of the project champion. When the driving force behind the project was transferred, the expert systems project stalled. The chapter discusses the difficulties in maintaining momentum for a project without a leader and presents suggestions for organizations so that they can avoid the pitfalls encountered.

Chapter 20 entitled, "Organizational Commitment in the IS Workplace: An Empirical Investigation of Its Antecedents and Implications" by Qiang Tu of Rochester Institute of Technology and Bhanu Raghunathan and T.S. Raghunathan of the University of Toledo (USA) attempts to fill a gap by empirically examining the relationships among a set of organizational and psychological factors and the organizational commitment of IS managers. The authors employed rigorous statistical analysis using the method of LISREL path. The results indicate that these variables are closely related to each other providing valuable insights for organizations to more effectively manage there IS human resources.

Information management in all its forms has revolutionized business, teaching and learning throughout the world. The chapters in this book address the most current topics in information management such as knowledge management, organizational commitment, implementing expert systems and assessing the relevance and value of IT to a variety of organizations. Academics and researchers will find the research discussed an excellent starting point for discussions and springboard for their own research. Practitioners and business people will find concrete advice on how to assess IT's use to their organization, how to most effectively use their human and IT resources and how to avoid the problems encountered by the organizations discussed in the above chapters. This book is a must read for all those interested in or utilizing information management in all its forms.

Mehdi Khosrowpour
Information Resources Management Association
October, 2001

Chapter I

Knowledge Management and New Organization Forms: A Framework for Business Model Innovation

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The concept of knowledge management is not new in information systems practice and research. However, radical changes in the business environment have suggested limitations of the traditional information-processing view of knowledge management. Specifically, it is being realized that the programmed nature of heuristics underlying such systems may be inadequate for coping with the demands imposed by the new business environments. New business environments are characterized not only by rapid pace of change but also discontinuous nature of such change. The new business environment, characterized by dynamically discontinuous change, requires a reconceptualization of knowledge management as it has been understood in information systems practice and research. One such conceptualization is proposed in the form of a sense-making model of knowledge management for new business environments. Application of this framework will facilitate business model innovation necessary for sustainable competitive advantage in the new business environment characterized by dynamic, discontinuous and radical pace of change.

> "People bring imagination and life to a transforming technology."–
> *Business Week*, The Internet Age (Special Report), October 4, 1999, p. 108.

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The traditional organizational business model, driven by prespecified plans and goals, aimed to ensure optimization and efficiencies based primarily on building consensus, convergence and compliance. Organizational information systems–as well as related performance and control systems–were modeled on the same paradigm to enable convergence by ensuring adherence to organizational routines built into formal and informal information systems. Such routinization of organizational goals for realizing increased efficiencies was suitable for the era marked by a relatively stable and predictable business environment. However, this model is increasingly inadequate in the e-business era, which is often characterized by an increasing pace of radical and unforeseen change in the business environment (Arthur, 1996; Barabba, 1998; Malhotra, 1998b; Kalakota & Robinson, 1999; Nadler et al., 1995).

The new era of dynamic and discontinuous change requires continual reassessment of organizational routines to ensure that organizational decision-making processes, as well as underlying assumptions, keep pace with the dynamically changing business environment. This issue poses increasing challenge as "best services" of yesterday–turn into "worst practices" and core competencies turn into core rigidities. The changing business environment, characterized by dynamically discontinuous change, requires a reconceptualization of knowledge management systems as they have been understood in information systems practice and research. One such conceptualization is proposed in this article in the form of a framework for developing organizational knowledge management systems for business model innovation. It is anticipated that application of this framework will facilitate development of new business models that are better suited to the new business environment characterized by dynamic, discontinuous and radical pace of change.

The popular technology-centric interpretations of knowledge management that have been prevalent in most of the information technology research and trade press are reviewed in the next section. The problems and caveats inherent in such interpretations are then discussed. The subsequent section discusses the demands imposed by the new business environments that require rethinking such conceptualizations of knowledge management and related information technology based systems. One conceptualization for overcoming the problems of prevalent interpretations and related assumptions is then discussed along with a framework for developing new organization forms and innovative business models. Subsequent discussion explains how the application of this framework can facilitate development of new business models that are better suited to the dynamic, discontinuous and radical pace of change characterizing the new business environment.

KNOWLEDGE MANAGEMENT: THE INFORMATION-PROCESSING PARADIGM

The information-processing view of knowledge management has been prevalent in information systems practice and research over the last few decades. This perspective originated in the era when the business environment was less vacillating, the products and services and the corresponding core competencies had a long multiyear shelf life, and the organizational and industry boundaries were clearly demarcated over the foreseeable future. The relatively structured and predictable business and competitive environment rewarded firms' focus on economies of scale. Such economies of scale were often based on high level of efficiencies of scale in absence of impending threat of rapid obsolescence of product and service definitions as well as demarcations of existing organizational and industry boundaries.

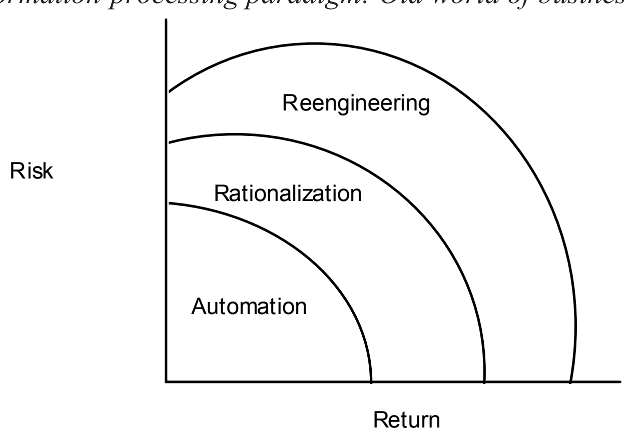
The evolution of the information-processing paradigm over the last four decades to build intelligence and manage change in business functions and processes has generally progressed over three phases:

1. *Automation*: increased efficiency of operations;
2. *Rationalization of procedures*: streamlining of procedures and eliminating obvious bottlenecks that are revealed by automation for enhanced efficiency of operations; and
3. *Reengineering*: radical redesign of business processes that depends upon information-technology-intensive radical redesign of work flows and work processes.

The information-processing paradigm has been prevalent over all three phases, which have been characterized by technology-intensive, optimization-driven, efficiency-seeking organizational change (Malhotra, 1999b, 1999c, in press). The deployment of information technologies in all three phases was based on a relatively predictable view of products and services as well as contributory organizational and industrial structures.

Despite increase in risks and corresponding returns relevant to the three kinds of information-technology-enabled organizational change, there was little, if any, emphasis on business model innovation–rethinking the business–as illustrated in Figure 1. Based on the consensus and convergence-oriented view of information systems, the information-processing view of knowledge management is often

Figure 1: Information-processing paradigm: Old world of business



characterized by benchmarking and transfer of best practices (Allee, 1997; O'Dell & Grayson, 1998). The key assumptions of the information-processing view are often based on the premise of the generalizability of issues across temporal and contextual frames of diverse organizations.

Such interpretations have often assumed that adaptive functioning of the organization can be based on explicit knowledge of individuals archived in corporate databases and technology-based knowledge repositories (Applegate, Cash & Mills, 1988, p. 44; italics added for emphasis):

> Information systems will maintain the corporate history, experience and expertise that long-term employees now hold. The information systems themselves–*not the people*–can become the stable structure of the organization. *People will be free to come and go, but the value of their experience will be incorporated in the systems* that help them and their successors run the business.

The information-processing view, evident in scores of definitions of knowledge management in the trade press, has considered organizational memory of the past as a reliable predictor of the dynamically and discontinuously changing business environment. Most such interpretations have also made simplistic assumptions about storing *past* knowledge of individuals in the form of routinized rules-of-thumb and best practices for guiding *future* action. A representative compilation of such interpretations of knowledge management is listed in Table 1.

Based primarily upon a static and "syntactic" notion of knowledge, such representations have often specified the *minutiae of machinery* while disregarding how people in organizations actually go about acquiring, sharing and creating new knowledge (Davenport, 1994). By considering the meaning of knowledge as "unproblematic, predefined, and prepackaged" (Boland, 1987), such interpretations of knowledge management have ignored the human dimension of organizational knowledge creation. *Prepackaged* or *taken-for-granted* interpretation of knowledge works against the generation of multiple and contradictory viewpoints that are *necessary* for meeting the challenge posed by *wicked environments* characterized by radical and discontinuous change: this may even hamper the firm's learning and adaptive capabilities (Gill, 1995). A key motivation of this article is to address the critical processes of *creation of new knowledge and renewal of existing knowledge* and to suggest a framework that can provide the philosophical and pragmatic bases for better representation and design of organizational knowledge management systems.

Philosophical Bases of the Information-Processing Model

Churchman (1971) had interpreted the viewpoints of philosophers Leibnitz, Locke, Kant, Hagel and Singer in the context of designing information systems. Mason and Mitroff (1973) had made preliminary suggestions for designing information systems based on Churchman's framework. A review of Churchman's inquiring systems, in context of the extant thinking on knowledge management,

Table 1: Knowledge management: The information-processing paradigm

The process of collecting, organizing, classifying and disseminating information throughout an organization, so as to make it purposeful to those who need it. (*Midrange Systems*: Albert, 1998)
Policies, procedures and technologies employed for operating a continuously updated linked pair of networked databases. (*Computerworld:* Anthes, 1991)
Partly as a reaction to downsizing, some organizations are now trying to use technology to capture the knowledge residing in the minds of their employees so it can be easily shared across the enterprise. Knowledge management aims to capture the knowledge that employees really need in a central repository and filter out the surplus. (*Forbes*: Bair, 1997)
Ensuring a complete development and implementation environment designed for use in a specific function requiring expert systems support. (*International Journal of Bank Marketing*: Chorafas, 1987)
Knowledge management IT concerns organizing and analyzing information in a company's computer databases so this knowledge can be readily shared throughout a company, instead of languishing in the department where it was created, inaccessible to other employees. (*CPA Journal*, 1998)
Identification of categories of knowledge needed to support the overall business strategy, assessment of current state of the firm's knowledge and transformation of the current knowledge base into a new and more powerful knowledge base by filling knowledge gaps. (*Computerworld*: Gopal & Gagnon, 1995)
Combining indexing, searching, and push technology to help companies organize data stored in multiple sources and deliver only relevant information to users. (*Information Week*: Hibbard, 1997)
Knowledge management in general tries to organize and make available important know-how, wherever and whenever it's needed. This includes processes, procedures, patents, reference works, formulas, "best practices," forecasts and fixes. Technologically, intranets, groupware, data warehouses, networks, bulletin boards, and videoconferencing are key tools for storing and distributing this intelligence. (*Computerworld*: Maglitta, 1996)
Mapping knowledge and information resources both on-line and off-line; training, guiding and equipping users with knowledge access tools; monitoring outside news and information. (*Computerworld*: Maglitta, 1995)
Knowledge management incorporates intelligent searching, categorization and accessing of data from disparate databases, e-mail and files. (*Computer Reseller News*: Willett & Copeland, 1998)
Understanding the relationships of data; identifying and documenting rules for managing data; and assuring that data are accurate and maintain integrity. (*Software Magazine*: Strapko, 1990)
Facilitation of autonomous coordinability of decentralized subsystems that can state and adapt to their own objectives. (*Human Systems Management*; Zeleny, 1987)

underscores the limitations of the dominant model of inquiring systems being used by today's organizations. Most technology-based conceptualizations of knowledge management have been primarily based upon heuristics–embedded in procedure manuals, mathematical models or programmed logic–that, arguably, capture the preferred solutions to the *given* repertoire of organizations' problems.

Following Churchman, such systems are best suited for:

(a) well-structured problem situations for which there exists strong *consensual* position on the nature of the problem situation, and

(b) well-structured problems for which there exists an analytic formulation with a solution.

Type (a) systems are classified as Lockean inquiry systems and type (b) systems are classified as Leibnitzian inquiry systems. Leibnitzian systems are closed systems without access to the external environment: they operate based on *given* axioms and may fall into competency traps based on diminishing returns from the "tried and tested" heuristics embedded in the inquiry processes. In contrast, the Lockean systems are based on consensual agreement and aim to reduce equivocality embedded in the diverse interpretations of the worldview. However, in absence of a consensus, these inquiry systems also tend to fail.

The *convergent* and *consensus building* emphasis of these two kinds of inquiry systems is suited for stable and predictable organizational environments. However, wicked environment imposes the need for variety and complexity of the interpretations that are necessary for deciphering the multiple world-views of the uncertain and unpredictable future.

BEYOND EXISTING MYTHS ABOUT KNOWLEDGE MANAGEMENT

The information-processing view of knowledge management has propagated some dangerous myths about knowledge management. Simplistic representations of knowledge management that often appear in popular press may often result in misdirected investments and system implementations that never yield expected returns (Strassmann, 1997, 1999).

Given the impending backlash against such simplistic representations of knowledge management (Garner, 1999), it is critical to analyze the myths underlying the "successful" representations of knowledge management that worked in a bygone era. There are three dominant myths based on the information-processing logic that are characteristic of most popular knowledge management interpretations (Hildebrand, 1999–Interview of the author with *CIO Enterprise* magazine).

Myth 1: ***Knowledge management technologies can deliver the right information to the right person at the right time.*** This idea applies to an outdated business model. Information systems in the old industrial model mirror the notion that businesses will change incrementally in an inherently stable market, and executives can foresee change by examining the past. The new business model of the Information Age, however, is marked by fundamental, not incremental, change. Businesses can't plan long-term; instead, they must shift to a more flexible "anticipation-of-surprise" model. Thus, it's impossible to build a system that predicts who the right person at the right time even is, let alone what constitutes the right information.

Myth 2: ***Knowledge management technologies can store human intelligence and experience.*** Technologies such as databases and groupware applications store bits and pixels of data, but they can't store the rich schemas that people possess for making sense of data bits. Moreover, information is context-sensitive. The same assemblage of data can evoke different responses from different people. Even the same assemblage of data when reviewed by the same person at a different time or in a different context could evoke differing response in terms of decision making and action. Hence, storing a static representation of the explicit representation of a person's knowledge–assuming one has the willingness and the ability to part with it–is not tantamount to storing human intelligence and experience.

Myth 3: ***Knowledge management technologies can distribute human intelligence***. Again, this assumes that companies can predict the right information to distribute and the right people to distribute it to. And bypassing the distribution issue by compiling a central repository of data for people to access doesn't solve the problem either. The fact of information archived in a database doesn't ensure that people will necessarily see or use the information. Most of our knowledge management technology concentrates on efficiency and creating a consensus-oriented view. The data archived in technological "knowledge repositories" is rational, static and without context and such systems do not account for *renewal of existing knowledge* and *creation of new knowledge*.

The above observations seem consistent with observations by industry experts such as John Seely-Brown (1997), who observed that: "In the last 20 years, U.S. industry has invested more than $1 trillion in technology, but has realized little improvement in the efficiency of its knowledge workers and virtually none in their effectiveness."

Given the dangerous perception about knowledge management as seamlessly entwined with technology, "its true critical success factors will be lost in the pleasing hum of servers, software and pipes" (Hildebrand, 1999). Hence, it is critical to focus the attention of those interested in knowledge management on the critical success factors that are necessary for business model innovation.

To distinguish from the *information-processing paradigm* of knowledge management discussed earlier, the proposed paradigm will be denoted as the *sense-making paradigm* of knowledge management. This proposed framework is based on Churchman's (1971, p. 10) explicit recognition that "knowledge resides in the user and not in the collection of information … it is how the user reacts to a collection of information that matters."

Churchman's emphasis on the human nature of knowledge creation seems more pertinent today than it seemed 25 years ago given the increasing prevalence of "wicked" environment characterized by discontinuous change (Nadler & Shaw, 1995) and "*wide range of potential surprise*" (Landau & Stout, 1979). Such an environment defeats the traditional organizational response of *predicting* and *reacting* based on preprogrammed heuristics. Instead, it demands more *anticipatory* responses from the organization members who need to carry out the mandate of a faster cycle of knowledge creation and action based on the new knowledge (Nadler & Shaw, 1995).

Philosophical Bases of the Proposed Model

Churchman had proposed two alternative kinds of inquiry systems that are particularly suited for multiplicity of worldviews needed for radically changing environments: Kantian inquiry systems and Hegelian inquiry systems. Kantian inquiry systems attempt to give multiple *explicit* views of *complementary* nature and are best suited for moderate, ill-structured problems. However, given that there is no explicit opposition to the multiple views, these systems may also be afflicted by competency traps characterized by *plurality* of *complementary* solutions. In contrast, Hegelian inquiry systems are based on a synthesis of *multiple completely antithetical* representations that are characterized by intense conflict because of the contrary underlying assumptions. Knowledge management systems based upon the Hegelian inquiry systems would facilitate multiple and contradictory interpretations of the focal information. This process would ensure that the "best practices" are subject to *continual* reexamination and modification given the dynamically changing business environment.

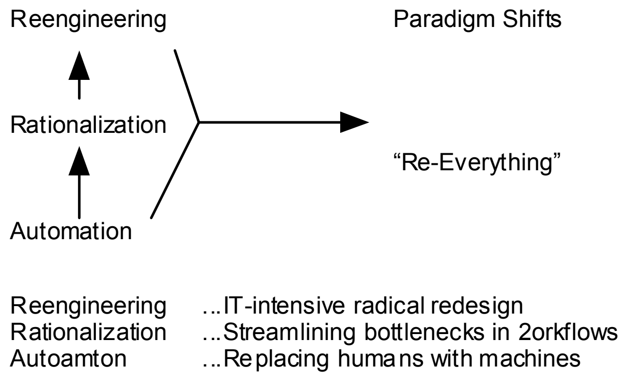
Given the increasingly wicked nature of business environment, there seems to be an imperative need for consideration of the Kantian and Hegelian inquiring systems that can provide the multiple, diverse, and contradictory interpretations. Such systems, by generating multiple *semantic* views of the future characterized by increasingly rapid pace of discontinuous change, would facilitate *anticipation of surprise* (Kerr, 1995) over prediction. They are most suited for dialectical inquiry based on dialogue: "meaning passing or moving through ... a free flow of meaning between people" (Bohm cited in Senge, 1990). The underpinning discussion asserts the *critical role* of the individual and social processes that underlie the *creation of meaning* (Strombach, 1986, p. 77), without which dialectical inquiry would not be possible. Therein lies the crucial sense-making role of humans in facilitating knowledge creation in inquiring organizations.

Continuously challenging the current "company way," such systems provide the basis for "creative abrasion" (Eisenhardt, Kahwajy & Bourgeois, 1997; Leonard, 1997) that is necessary for promoting radical analysis for business model innovation. In essence, knowledge management systems based on the proposed model prevent the *core capabilities* of yesterday from becoming *core rigidities* of tomorrow (Leonard-Barton, 1995). It is critical to look at knowledge management beyond its representation as "know what you know and profit from it" (Fryer, 1999) to "obsolete what you know before others obsolete it and profit by creating the challenges and opportunities others haven't even thought about" (Malhotra, 1999d). This is the new paradigm of knowledge management for radical innovation required for sustainable competitive advantage in a business environment characterized by radical and discontinuous pace of change.

KNOWLEDGE MANAGEMENT FOR BUSINESS MODEL INNOVATION: FROM BEST PRACTICES TO PARADIGM SHIFTS

As discussed above, in contrast to the information-processing model based on deterministic assumptions about predictability of the future, the sense-making

Figure 2: From best practices to paradigm shifts



model is more conducive for sustaining competitive advantage in the "world of re-everything" (Arthur, 1996). Without such radical innovation, one wouldn't have observed the paradigm shifts in core value propositions served by new business models.

Such rethinking of the nature of the business and the nature of the organization itself characterizes paradigm shifts that are the hallmark of business model innovation. Such paradigm shifts will be attributable for about 70% of the *previously unforeseen* competitive players that many established organizations will encounter in their future (Hamel, 1997).

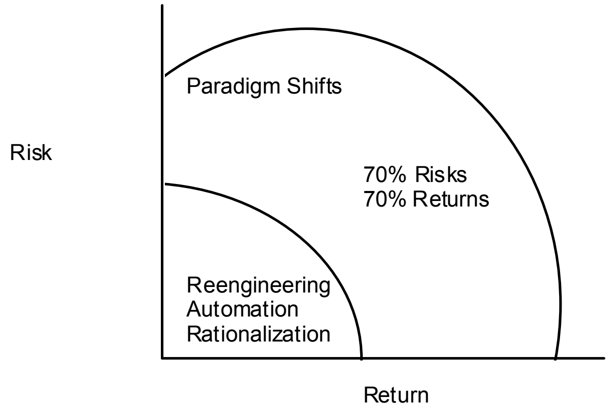
Examples of such new business models include Amazon.com and eToys, relatively new entrants that are threatening traditional business models embodied in organizations such as Barnes & Noble and Toys "R" Us. Such business model innovations represent "paradigm shifts" that characterize not transformation at the level of business processes and process work flows, but radical rethinking of the business as well as the dividing lines between organizations and industries.

Such paradigm shifts are critical for overcoming managers' "blindness to developments occurring *outside* their core [operations and business segments]" and tapping the opportunities in "white spaces" that lie between existing markets and operations (Moore, 1998).

The notions of "best practices" and "benchmarking" relate to the model of organizational controls that are "built, a priori, on the principal of closure" (Landau & Stout, 1979, p. 150; Stout, 1980) to seek compliance to, and convergence of, the organizational decision-making processes (Flamholtz, Das & Tsui, 1985). However, the decision rules embedded in "best practices" assume the character of predictive "proclamations" which draw their legitimacy from the vested authority, not because they provide adequate solutions (Hamel & Prahalad, 1994, p. 145). Challenges to such decision rules tend to be perceived as challenges to the authority embedded in "best practices" (Landau, 1973).

Hence, such "best practices" that *ensure* conformity by ensuring task definition, measurement and control also *inhibit* creativity and initiative (Bartlett &

Figure 3: Paradigm shifts: New world of business



Ghoshal, 1995; Ghoshal & Bartlett 1995). The system that is structured as a "core capability" suited to a relatively static business environment turns into a "core rigidity" in a discontinuously changing business environment. Despite the transient efficacy of "best practices," the cycle of doing "more of the same" tends to result in locked-in behavior patterns that eventually sacrifice organizational performance at the altar of the organizational "death spiral" (Nadler & Shaw 1995, p. 12-13). In the e-business era, which is increasingly characterized by faster cycle time, greater competition, and lesser stability, certainty and predictability, any kind of consensus cannot keep pace with the dynamically discontinuous changes in the business environment (Bartlett & Ghoshal 1995; Drucker, 1994; Ghoshal & Bartlett, 1996).

With its key emphasis on the obedience of rules embedded in "best practices" and "benchmarks" at the cost of correction of errors (Landau & Stout, 1979), the information-processing model of knowledge management limits creation of *new* organizational knowledge and impedes renewal of existing organizational knowledge.

Most of the innovative business models such as Cisco and Amazon.com didn't devolve from the best practices or benchmarks of the organizations of yesterday that they displaced, but from radical re-conceptualization of the nature of the business. These paradigm shifts are also increasingly expected to challenge the traditional concepts of organization and industry (Mathur & Kenyon, 1997) with the emergence of *business ecosystems* (Moore, 1998), *virtual communities of practice* (Hagel & Armstrong, 1997) and *infomediaries* (Hagel & Singer, 1999).

HUMAN ASPECTS OF KNOWLEDGE CREATION AND KNOWLEDGE RENEWAL

Knowledge management technologies based upon the information-processing model are limited in the capabilities for creation of new knowledge or renewal of existing knowledge. No doubt, such technologies provide the optimization-driven, efficiency-seeking behavior needed for high performance and success in a business environment characterized by a predictable and incremental pace of change. Examples of technologies that are based on a high level of integration such as ERP technologies represent knowledge management technologies based upon the information-processing model. However, given a radical and discontinuously changing business environment, these technologies fall short of sensing changes that they haven't been preprogrammed to sense and accordingly are unable to modify the logic underlying their behavior.

Until information systems embedded in technology become capable of *anticipating change* and changing their basic assumptions (heuristics) accordingly, we would need to rely upon humans for performing the increasingly relevant function of self-adaptation and knowledge creation. However, the vision of information systems that can autonomously revamp their past history based upon their anticipation of future change is yet far from reality (Wolpert, 1996). Given the constraints inherent in the extant mechanistic (programmed) nature of technology, the human element assumes greater relevance for maintaining currency of the programmed heuristics (programmed routines based upon previous assumptions). Therefore, the human function of ensuring the *reality check*–by means of repetitive questioning, interpretation and revision of the assumptions underlying the information system–assumes an increasingly important role in the era marked by discontinuous change.

The human aspects of knowledge creation and knowledge renewal that are difficult–if not impossibl–to replace by knowledge management technologies are listed below.

- Imagination and creativity latent in human minds
- Untapped tacit dimensions of knowledge creation
- Subjective and meaning-making bases of knowledge creation
- Constructive aspects of knowledge creation and renewal

The following discussion explains these issues in greater detail and suggests how they can help overcome the limitations of the information-processing model of knowledge management.

Imagination and Creativity Latent in Human Minds: Knowledge management solutions characterized by memorization of "best practices" may tend to define the assumptions that are embedded not only in information databases, but also in the organization's strategy, reward systems and resource allocation systems. The *hardwiring* of such assumptions in organizational knowledge bases may lead to perceptual insensitivity (Hedberg, Nystrom & Starbuck, 1976) of the organization to the changing environment. Institutionalization of "best practices" by embedding them in information technology might facilitate efficient handling of routine, "linear," and predictable situations during stable or incrementally changing environments. However, when this change is discontinuous, there is a persistent need for continuous renewal of the basic premises underlying the "best practices" stored in organizational knowledge bases. The information-processing model of knowledge management is devoid of such capabilities which are essential for continuous learning *and* unlearning mandated by radical and discontinuous change. A more proactive involvement of the human imagination and creativity (March, 1971) is needed to facilitate greater internal diversity (of the organization) that can match the variety and complexity of the wicked environment.

Untapped Tacit Dimensions of Knowledge Creation: The information-processing model of knowledge management ignores tacit knowledge deeply rooted in the individual's action and experience, ideals, values, or emotions (Nonaka & Takeuchi, 1995). Although tacit knowledge lies at the very basis of organizational knowledge creation, its nature renders it highly personal and hard to formalize and to communicate. Nonaka and Takeuchi (1995) have suggested that knowledge is created through four different modes: (1) *socialization*, which involves conversion from tacit knowledge to tacit knowledge, (2) *externalization*, which involves conversion from tacit knowledge to explicit knowledge, (3) *combination*, which involves conversion from explicit knowledge to explicit knowledge, and (4) *internalization*, which involves conversion from explicit knowledge to tacit knowledge. The dominant model of inquiring systems is limited in its ability to foster shared experience necessary for relating to others' thinking processes, thus limiting its utility in *socialization*. It may, by virtue of its ability to convert tacit knowledge into explicit forms such as metaphors, analogies and models, have some utility in *externalization*. This utility is however restricted by its ability to support dialogue or collective reflection. The current model of inquiring systems, apparently, may have a greater role in *combination*, involving combining different bodies of explicit knowledge, and *internalization*, which involves knowledge transfer through verbalizing or diagramming into documents, manuals and stories. A more explicit recognition of tacit knowledge and related human aspects, such as ideals, values, or emotions, is necessary for developing a richer conceptualization of knowledge management.

Subjective and Meaning-Making Bases of Knowledge Creation: Wicked environments call for interpretation of new events and ongoing reinterpretation and reanalysis of assumptions underlying extant practices. However, the information-processing model of knowledge management largely ignores the important construct of *meaning* (Boland, 1987) as well as its transient and ambiguous nature. "Prepackaged" or "taken-for-granted" interpretation of knowledge residing in the organizational memories works against generation of multiple and contradictory viewpoints necessary for ill-structured environments. Simplification of contextual information for storage in IT-enabled repositories works against the retention of the complexity of multiple viewpoints. Institutionalization of definitions and interpretations of events and issues works against the exchanging and sharing of diverse perspectives. To some extent the current knowledge management technologies, based on their ability to communicate metaphors, analogies and stories by using multimedia technologies, may offer some representation and communication of meaning. However, a more human-centric view of knowledge creation is necessary to enable the interpretative, subjective and meaning-making nature of knowledge creation. Investing in multiple and diverse interpretations is expected to enable

Kantian and Hegelian modes of inquiry and, thus, lessen oversimplification or premature decision closure.

Constructive Aspects of Knowledge Creation and Renewal: The information-processing model of knowledge management ignores the constructive nature of knowledge creation and instead assumes a prespecified meaning of the memorized "best practices" devoid of ambiguity or contradiction. It ignores the critical process that translates information into meaning and action that is necessary for understanding knowledge-based performance (Bruner, 1973; Dewey, 1933; Malhotra, 1999a; Malhotra & Kirsch, 1996; Strombach, 1986). The dominant model of inquiring systems downplays the constructive nature of knowledge creation and action. For most ill-structured situations, it is difficult to ensure a unique interpretation of "best practices" residing in information repositories since knowledge is created *by the individuals* in the process of using that data. Even if prespecified interpretations could be possible, they would be problematic when future solutions need to be either thought afresh or in discontinuation from past solutions. Interestingly, the constructive aspect of knowledge creation is also expected to enable multiple interpretations that can facilitate the organization's *anticipatory response* to discontinuous change.

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

This proposed sense-making model of knowledge management enables the organizational knowledge creation process that is "both *participative* and *anticipative*" (Bennis & Nanus, 1985, p. 209). Instead of a formal rule- or procedure-based step-by-step rational guide, this model favors a "set of guiding principles" for helping people understand "not how it should be done" but "how to understand what might fit the situation they are in" (Kanter, 1983, pp. 305-306). This model assumes the existence of "only a few rules, some specific information and a lot of freedom" (Margaret Wheatley cited in Stuart, 1995). One model organization that has proven the long-term success of this approach is Nordstrom, the retailer that has a sustained reputation for its high level of customer service. Surprisingly, the excellence of this organization derives from its one-sentence employee policy manual that states (Taylor, 1994): "Use your good judgment in all situations. There will be no additional rules." The primary responsibility of most supervisors is to continuously coach the employees about this philosophy for carrying out the organizational pursuit of "serving the customer better" (Peters, 1989, p. 379).

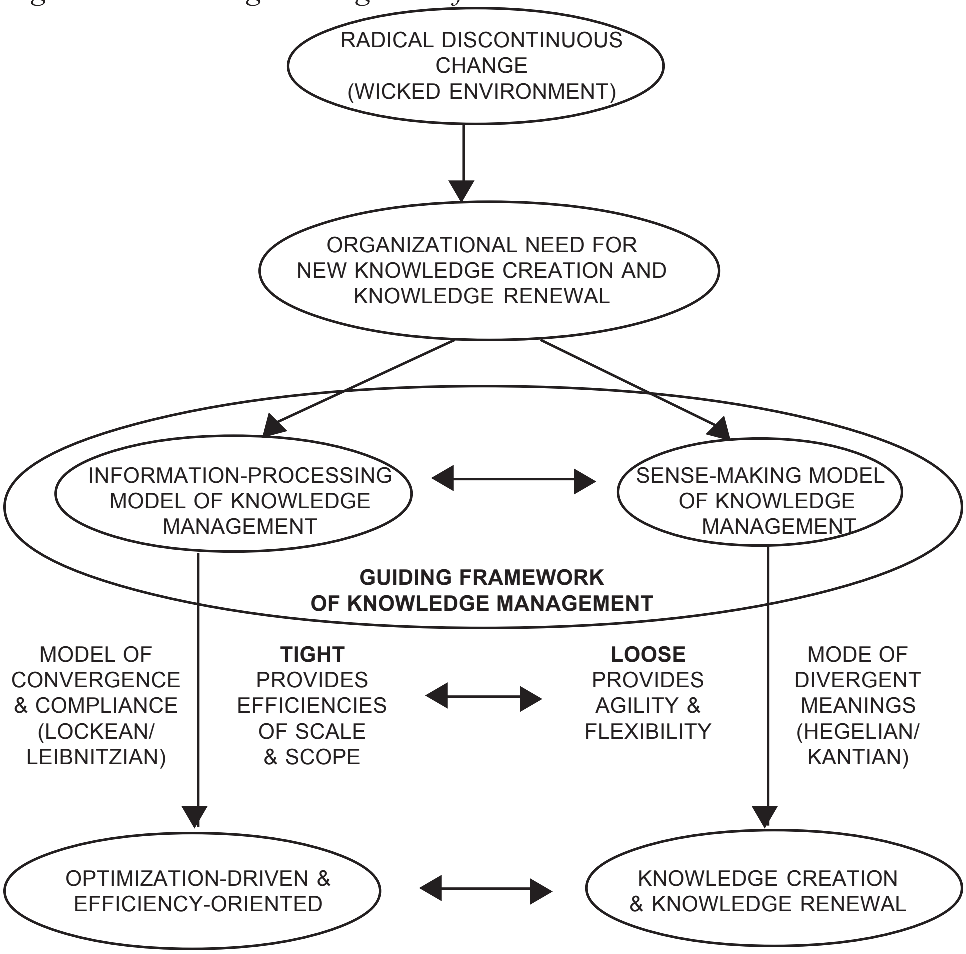
The proposed model, illustrated in Figure 4, is anticipated to advance the current conception of "knowledge-tone" and related e-business applications (Kalakota & Robinson, 1999) beyond the performance threshold of highly integrated technology-based systems. By drawing upon the strengths of both convergence-driven (Lockean-Leibnitzian) systems and divergence-oriented (Hegelian-Kantian) systems, the proposed model offers both a combination of flexibility and agility while ensuring efficiencies of the current technology architecture. Such systems are *loose* in the sense that they allow for continuous reexamination of the assumptions underlying best practices and reinterpretation of this information. Such systems are *tight* in the sense that they also allow for efficiencies based on propagation and dissemination of the best practices.

The knowledge management systems based on the proposed model do not completely ignore the notion of "best practices" per se but consider the continuous construction and reconstruction of such practices as a dynamic and ongoing process. Such *loose-tight knowledge management systems* (Malhotra, 1998a) would need to provide not only for identification and dissemination of best practices, but also for continuous reexamination of such practices. Specifically, they would need to also include a simultaneous process that continuously examines the best practices for their currency given the changing assumptions about the business environment. Such systems would need to contain *both* learning and unlearning processes. These simultaneous processes are needed for assuring the efficiency-oriented optimization based on the current best practices while ensuring that such practices are continuously reexamined for their viability.

Some management experts (Manville & Foote, 1996) have discussed selected aspects of the proposed *sense-making model of knowledge management* in terms of the shift from the traditional emphasis on transaction processing, integrated logistics, and work flows to systems that support competencies for communication building, people networks, trust building and on-the-job learning. Many such *critical success factors* for knowledge management require a richer understanding of human behavior in terms of their perceptions about living, learning and working in technology-mediated and cyberspace-based environments.

Some experts (Davenport & Prusak, 1998, Romer in Silverstone, 1999) have emphasized formal incentive systems for motivating loyalty of employees for sustaining the firm's intellectual capital and loyalty of customers for sustaining "stickiness" of portals. However, given recent findings in the realms of performance and motivation of individuals (Malhotra, 1998c; Kohn, 1995) using those systems, these assertions need to be reassessed. The need for better understanding of human factors underpinning performance of knowledge management technologies is also supported by our observation of informal "knowledge sharing" virtual communities of practice affiliated with various Net-based businesses (Knowledge Management Think Tank at: forums.brint.com) and related innovative business models. In most such cyber-communities, success, performance and "stickiness" are often driven by *hi-touch* technology environments that effectively address the core value proposition of the virtual community. It is suggested that the critical success factors of the proposed model of knowledge management for business innovation are supported by a redefinition of "control" (Flamholtz et al., 1985; Malhotra & Kirsch, 1996; Manz et al., 1987; Manz & Sims, 1989) as it relates to the new living, learning and working environments afforded by emerging business models. Hence, business model innovation needs to be informed by the proposed model of knowledge management that is based upon synergy of the information-processing capacity of information technologies and the sense-making capabilities of humans.

Figure 4: Knowledge management for business model innovation



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Chapter II

Using a Metadata Framework To Improve Data Resources Quality

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The importance of properly managing the quality of organizational data resources is widely recognized. A metadata framework is presented as the critical tool in addressing the necessary requirements to ensure data quality. This is particularly useful in increasingly encountered complex situations where data usage crosses system boundaries. The basic concept of metadata quality as a foundation for data quality engineering is discussed, as well as an extended data life cycle model consisting of eight phases: metadata creation, metadata structuring, metadata refinement, data creation, data utilization, data assessment, data refinement, and data manipulation. This extended model will enable further development of life cycle phase-specific data quality engineering methods. The paper also expands the concept of applicable data quality dimensions, presenting data quality as a function of four distinct components: data value quality, data representation quality, data model quality, and data architecture quality. Each of these, in turn, is described in terms of specific data quality attributes.

The importance of a company-wide framework for managing data resources has been recognized (Gunter, 2001; Sawhney, 2001; Stewart, 2001). It is considered a major component of information resources management (Guimaraes, 1988). The complexity of data resources management is increasing as computer applications become more accessible to mobile users (Nesdore, 2001) and organizations attempt to extract more value from their data (Webb, 1999). As the volume, importance, and complexity of data management increases, many organizations are discovering that imperfect data in information systems negatively affects their business operations and can be extremely costly (Brown, 2001). Results from a survey indicate fifty percent of IS managers reported losing valuable data in the last two years and at least twenty percent with losses costing $1 million or more (Panettieri, 1995). Another survey reports 70% of the IS managers having their business processes interrupted at least once due to imperfect data (Wilson, 1992). Still another study showed that the nature of the problems associated with defective data ranges widely, from damaged files and lost data accounting for 23 percent of the responses, cost overruns (17%), conflicting reports (16%), improper regulatory reporting (13%), improper billing (9%), poor decisions (7%), delivery delays or errors (6%), and others (9%) (Knight, 1992).

We believe imperfect data can result from practice-oriented and structure-oriented causes. Practice-oriented causes result in systems capturing or manipulating imperfect data (i.e., not designing proper edit checking into data capturing methods or allowing imprecise/incorrect data to be collected when requirements call for more precise or more accurate data). Operational in nature, practice-oriented causes are diagnosed bottom-up and typically can be addressed by the imposition of more rigorous data handling methods. Structure-oriented causes of imperfect data occur when there exists a mismatch between user requirements and the physical data implementation designed to meet the requirements. The imperfections are inadvertently designed into the implementation. Correcting structural causes more often requires fundamental changes to the data structures and is typically implemented top-down. Structural problems result when a user cannot obtain desired results due to lack of access and/or lack of understanding of data structure, as opposed to getting an incorrect value or representation.

Adopting an organization-wide perspective to data quality engineering integrates development activities using data architecture. Failure to develop systems as coordinated architecture components results in fragmented data resources whose definitions apply at best within system boundaries. One additional consequence is that data interchange among company systems and those of partner organizations is more difficult. Structurally defective data results in unfavorable outcomes such as: 1) providing the correct response but the wrong data to a user query because the user did not comprehend the system data structure; 2) organizational maintenance of inconsistent data used by redundant systems; or 3) data not supplied at all due to deletion anomalies (i.e., storing multiple facts in the same physical entity).

Previous studies of data quality have addressed practice-oriented causes of imperfect data with data quality engineering methods such as those reported by English (1996) and Broussard (1994). Less guidance has been available to organizations interested in addressing the problems creating structurally defective data and how it relates to the comprehensive dimensions of data quality engineering.

With the strong trend toward more integrated systems within and among organizations on a global scale, clearly defined data resources and management guidelines are increasingly required for situations where data crosses system boundaries. Many researchers have contributed to the evolution of a data life cycle model. We seek to build on previous work illustrating how a better understanding of the data life cycle results in better matches of data quality engineering techniques with life cycle phases.

Similarly, previous studies on data quality have identified the dimensions necessary to ensure data quality within system boundaries. Collectively the research work has resulted in a data quality model with three dimensions (data model, data value, and data representation), as reported by several authors such as Reingruber and Gregory (1994) and Fox, Levitin, and Redman (1994). As mentioned earlier, attempts to define data quality engineering methods have focused on correction of operational problems, addressing these three quality dimensions and directing attention to practice oriented data imperfections.

The objective of this paper is to present an expanded data quality model that addresses practice-oriented as well as structure-oriented causes of imperfect data. The expanded data life cycle model proposed here enables us to identify links between cycle phases and data quality engineering dimensions. Expanding the data life cycle model and the dimensions of data quality will enable organizations to more effectively implement the inter- as well as intra-system use of their data resources, as well as better coordinate the development and application of their data quality engineering methods.

The next section of the paper defines the theoretical foundation for the paper. That is followed by a proposal to extend the existing conceptual model for data management with a data life cycle model consisting of eight phases: metadata creation, metadata structuring, metadata refinement, data creation, data utilization, data manipulation, data assessment, and data refinement. In turn, that is followed by a section outlining an expanded view of data quality engineering as encompassing four dimensions: data representation, data value, data model and data architecture, each with their specific set of attributes necessary to ensure data quality. The last section contains a short summary and some final conclusions for managers in this increasingly important area.

THE THEORETICAL FRAMEWORK

Semantically, data are a combination of facts and meanings (Appleton, 1984). When implemented, the logical label "meaning" can be replaced with the physical implementation term "data entity structure" (DES). The physical implementation of a DES is an entity/attribute combination. A data value is a combination of a fact and a DES specifying an entity/attribute combination–Tsichritzis and Fochovski (1982) labeled this structure a triple. Based on present practice within most organizations, triples can have organization-wide scope, but system managers consider themselves fortunate to have them consistently applied within a system and spend consideration trying to manage multiple triple variations within a single system.

Based on a widely accepted definition, when data are supplied in response to a user request, they become information. For example, a DES associates a fact (23 beds) with a specific meaning (average occupancy of Ward C for Quarter 2). As a triple, this is provided in response to a hospital manager request inquiring as to the average number of beds occupied during the second quarter. The same triple is reused to respond to other information requests: How effective was the advertising? What was the perceived product quality? Can we measure market penetration? If technology didn't permit association of individual facts with multiple meanings, the data maintenance required to supply requested information would require more resources. Reusing DESs permits organizations to provide a relatively wide range/ large amount of information by managing a smaller amount of data.

Also widely accepted is the importance of metadata describing specific data characteristics. Facts describing organizational data quality are one type of metadata. One instance of data quality metadata is the association among data model entities sharing common keys (model metadata). Data model metadata describes structured DES components used to represent user requirements. Data models represent these associations of respective triples with correct representation of user requirements and physical implementations. Another type of metadata important to data quality is the association among organizational data models (architectural metadata) which represent a major component for organizational data architecture. It includes information on the relevant entities and attributes, such as their names, definitions, a purpose statement describing why the organization is maintaining information about this business concept, their sources, logical structures, value encoding, stewardship requirements, business rules, models associations, file designs, data uses, specifications, repositories, etc. This architecture is a critical framework facilitating communication, thoughts, and actions among developers and data resources users. It works as the blueprint or master plan guiding and promoting data sharing by providing common organizational and industry-wide data definitions and DES. Thus, it enables higher degrees of organizational technological dexterity.

Graphically, Figure 1 shows how a data architecture can be used to coordinate the implementation of different physical data models by mapping individual data records of the physical implementation to components of the organizational data model, thus promoting and supporting organization-wide use of standard data definitions.

DATA MANAGEMENT CONCEPTUAL EVOLUTION: AN EXTENDED MODEL

Levitin and Redman (1993) recognized distinctions between data acquisition and data use cycles in their data life cycle. Their efforts focused on identifying the data quality characteristics desirable for each cycle, the data quality within systems. Data was stored between cycles (Figure 2). Their model describes activities transforming the data as: data view development, data value acquisition, data value storage, and data utilization.

Figure 3 hereby proposes an extension to the model presented in Figure 2. The proposed model has a number of inputs/outputs distributed about eight phases: metadata creation, metadata structuring, metadata refinement, data creation, data utilization, data assessment, data refinement, and data manipulation. Each of these phases are described below in more detail.

Two possible cycle "starting points" are shown bolded in Figure 3. The first starting point is applicable to new systems where there exists no data to be migrated and/or converted from existing system(s). In these instances, the model cycle begins with metadata creation and proceeds counterclockwise around the cycle. However, according to a recent survey of CIOs by Deloitte & Touche (1998), an average of more than 90% of organizational legacy systems is scheduled to be replaced in the next 5 years. Thus, it is more likely that organization legacy data will become the

Figure 1: Data architecture used to guide the development of different data models

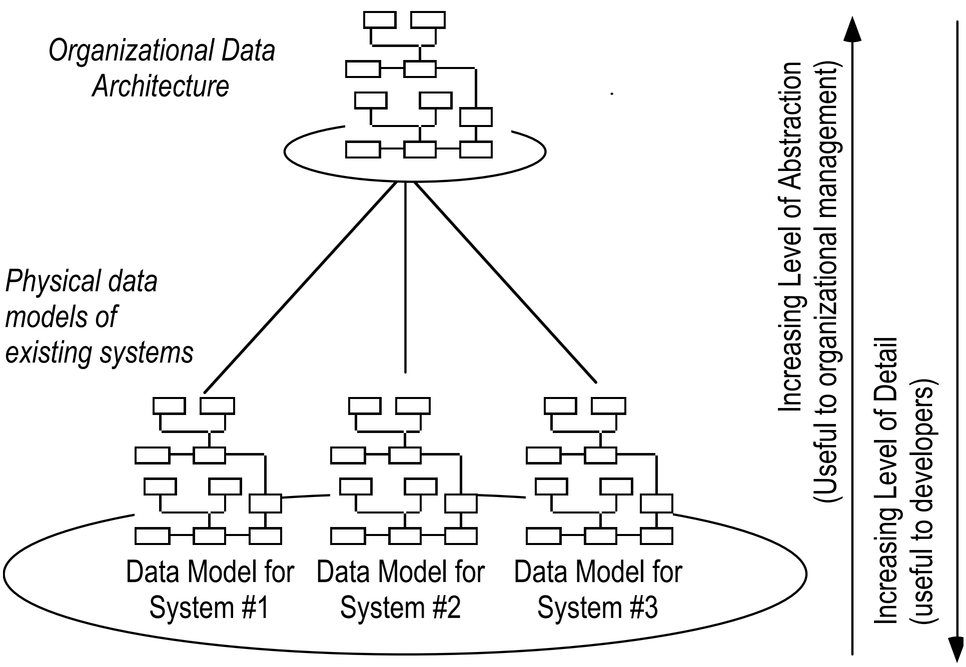


Figure 2: Data acquisition and usage cycles (Levitin & Redman, 1993)

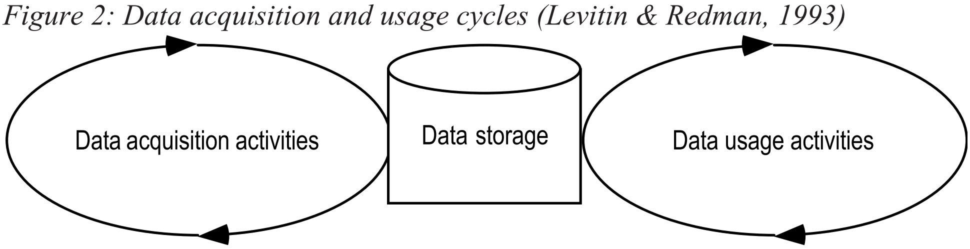
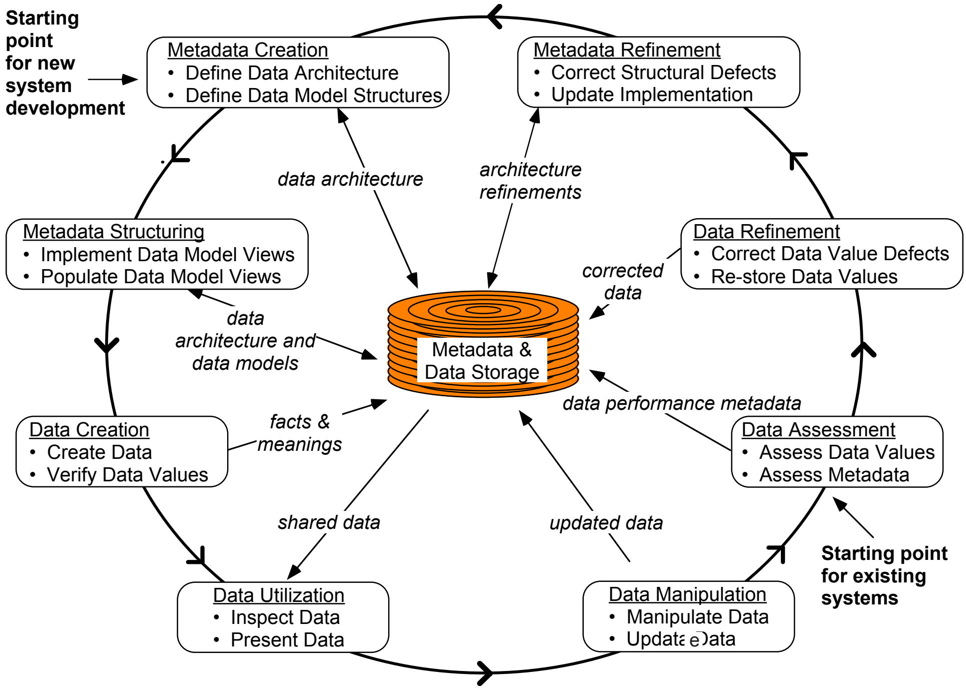


Figure 3: Newly proposed eight phases of extended data life cycle model with metadata sources and uses



major data asset to be managed. In these cases where data already exists, structural data quality reengineering becomes necessary, and the cycle begins with data assessment. Next, each cycle phase is described in more detail.

Metadata Creation: When the requirements dictate that users interact with multiple systems across functional area boundaries, a formal organizational data architecture is required to coordinate data quality engineering efforts. While all organizations have data architectures, only formally specified architectures can be formally managed. This phase typically corresponds to increasing awareness of data as an organizational asset. The architectural metadata created and evolved consists of the organizational data architecture structure definitions and specific associations among individual system data models.

Metadata Structuring: This phase focuses on developing a framework guiding the organizational data architecture implementation as it populates data models in the next phase. Metadata creation is followed by the development of a data model structure. Data models must also be evolved. The term "structuring" indicates the iterative development process that occurs as the organizational data architecture structure developed during the previous phase is populated with metadata. Defining data model structures permits organizations to understand the categories of data that comprise its data models. The process consists of populating the data architecture with data models describing the various specific systems. Each data model corresponds to one physical occurrence. In addition, when physically implemented, logical model components can be physically implemented by multiple systems, accessing common DESs. The process of defining data models as components extends the organizational data architecture comprehensiveness. Metadata structuring is complete when all entities can be associated with specific model components. Perfect model metadata occurs when a correct data model exists for each physical system, and each physical system component is associated with one and only one common organizational data architecture component.

Metadata Refinement: At various points, portions of some metadata can be determined imperfect. Architecture refinement implements an iterative approach to refining the existing metadata-based concepts, correcting factual errors, and evolving the structure to a more perfect state. This usually occurs in response to data assessment activities.

Data Creation: Data creation occurs when data values are captured from some external source and stored in systems. Data sources can range from a point of sale terminal, to EDI, to floppy disk exchange. Data creation is the most popular focus of data quality engineering efforts. These are commonly implemented as edit masking, range checking, or other forms of validation. Data value quality efforts are aimed at perfecting data values as they are captured and before they are stored or re-stored in the database.

Data Utilization: Data utilization occurs as the data is provided as information in response to a request from a user or a process. The focus of data quality engineering efforts for this phase IS on appropriate data representation; i.e., taking data from a storage location and properly presenting it to a user or a process as requested.

Data Assessment: This often occurs in response to complaints of imperfect data. It is assessed formally or informally to determine data suitability for current or future use. If data is judged inadequate, the assessment also determines if the problem causes are practice-caused or structurally caused. Practice-caused problems are corrected through the data refinement phase, while structural problems are amended through the metadata refinement, creation, and structuring phases. Structural changes must be applied at an organizational architecture level.

Data Refinement: If the cause of imperfect data is determined to be practice-oriented, the data values are corrected using a data refinement procedure. Data refinement refers to the process of altering data within the existing data structures. This continues to be a popular focus of data value quality engineering efforts.

Data Manipulation: Often-times data is accessed to be altered, deleted, or otherwise manipulated. Data manipulation is the process of altering data forms or data values. Any change can introduce error, and the data quality engineering focus is similar to that described above.

DATA QUALITY ENGINEERING EVOLUTION: A NEW DIMENSION

Previous research has defined specific attributes characterizing the representation, value, and data model quality dimensions. The data value quality dimension refers to the quality of data as stored and maintained in the system as a fact/DES combination composed of specific entities and attributes. The data representation quality dimension refers to the quality of representation for stored data values. Perfect data values stored in a system that are inappropriately represented to the user can be harmful. Because end users deal with data represented as abstract data entities and/or values, this dimension focuses on the process of representing the data values to the end users during data utilization. The data model quality dimension refers to the quality of data logically representing user requirements related to data entities, associated attributes, and their relationships. A quality data model is essential to communicate among users and system developers about data structure specifications.

The most fundamental aspect of data quality is whether the system is maintaining data which are useful to the user community. No other data quality characteristic matters if the necessary data are defective or not available. Several studies pointed out the widespread occurrences of incorrect data values (i.e., Ballou & Tayi, 1989; Laudon, 1986; Morey, 1982; O'Brien, 1993; Tsichritzis & Fochovski, 1982). Meanwhile, the definition of data quality has been evolving. Originally, data quality engineering was mostly focused on data values maintained by information systems, and data quality research was mostly based on the value triplet component defined earlier.

Work by Tufte (1990) and others such as Fox et al. (1994), Redman (1992), and O'Brien (1993) indicated that correct data values can create great problems, as in the Challenger disaster case described by Tufte as a failure of administrators to understand the data representation proposed by the engineers. Because users deal with data as represented (not as abstract data entities and/or values) the definition of data quality was extended towards the user community, resulting in a second dimension: data representation. For this dimension, data quality efforts are focused on properly representing the triplet value component to the user.

Recognizing the need for a third data quality dimension, Reingruber and Gregory (1994) and Fox et al. (1994) describe how data quality depends on the quality of the data model defining the entities and attributes relevant to the user application. Data models focus on structuring the entity and attribute portions of the triplet to represent user requirements. As said earlier, a quality data model is essential for effective communications among developers and users regarding data structure specifications, but it also incorporates more of a systems developer perspective, something lacking in the first two dimensions.

Developers have typically been task-oriented when developing specific systems based on data modeling. Most data quality methods are also usually system-focused, limiting their usefulness beyond the specific system boundaries. From an organizational perspective, absence of data definitions shared across functional areas makes data interchange among systems considerably more difficult. Thus, quality considerations based on these three dimensions can be insufficient to insure overall data quality. The increasingly widespread requirement that users interact with multiple systems and the need for developers to build more highly integrated systems demand an additional data quality dimension. Therefore, we propose a fourth dimension to data quality which addresses organizational data architecture, to coordinate data management activities in cross-functional system development and operations. The chief characteristic of this dimension is an architecture providing an effective linkage between the organization-wide user data requirements and the specific systems implemented to satisfy such requirements.

Some researchers have recognized the importance of data architecture in general (Spewak, 1993). However, the specific requirements for an additional dimension which provides organization-wide perspective to data management to ensure its quality in cross-functional system development and operation have been neglected. Data quality engineering has been focused on metadata management from a top-down perspective. The proposed expansion of data quality dimensions incorporates the data architecture component, which refers to the quality of metadata defined with an organization-wide perspective, providing data definition shared across functional areas and interorganizations whenever necessary to coordinate data interchange among information systems.

From another perspective, various inputs and outputs of the eight phases in the proposed data life cycle model can be organized into four data products: 1) organizational data architecture components; 2) a series of related data models; 3) specific data values; and 4) data representation descriptions. Effective data quality engineering depends on identifying the quality measures applicable to each of these four data products and applying them in the appropriate phase. The quality of these four data products determines overall organizational data quality, and perfecting all of them should be the focus of data quality engineering efforts within organizations. Therefore, this study extends the concepts of data quality dimensions, presenting data quality as a function of four distinct components: data value quality, data representation quality, data model quality, and data architecture quality, as shown in Figure 4.

Furthermore, as shown in Figure 5, the four dimensions can be structured hierarchically, to implement the specification that organizational data architecture is comprised of one or more data models. Each, in turn, specifies physical maintenance of one or more data values, which, in turn, can be presented to various users with one or more data representations.

Effective data quality engineering requires application of the appropriate method during the appropriate life cycle phase. Figure 6 shows that each of these four quality dimensions is the primary focus within different phases in the data life cycle model proposed earlier.

From another perspective, Figure 7 illustrates how these four dimensions of data quality engineering correspond to the various data view perspectives. The quality of a

Figure 4: Extended model of data quality dimensions

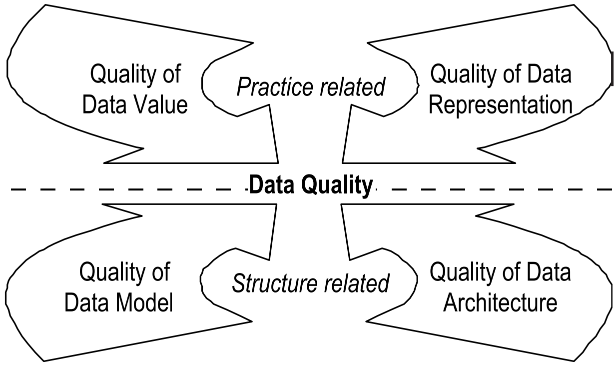


Figure 5: Hierarchical relationship of the four data quality dimensions

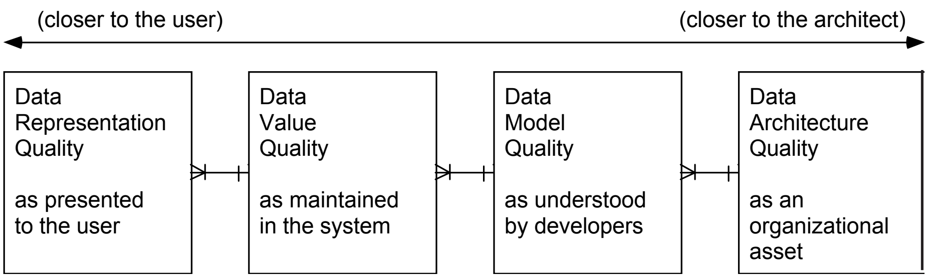


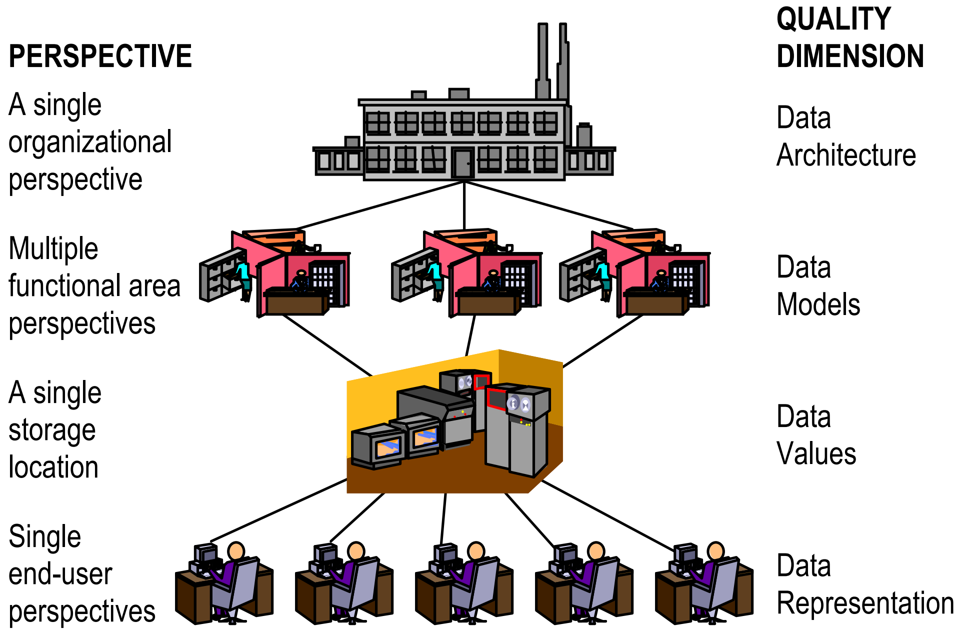
Figure 6: Metamodel quality dimensions related to data model life cycle phases

Dimension	Focus/Phase:	Metadata Refinement	Metadata Creation	Metadata Structuring	Data Creation	Data Manipulation	Data Refinement	Data Utilization	Data Assessment
Data Architecture Quality	Data architecture quality is the focus of metadata creation & refinement efforts.	↵	↵						↵
Data Model Quality	Data model quality is the focus of metadata refinement & structuring efforts.			↵	↵	↵	↵		↵
Data Value Quality	Data value quality is the focus of the data creation and manipulation and refinement phases.								↵
Data Representation Quality	Data representation quality is the focus of the data utilization phase.							↵	↵

data architecture is determined by its capability to provide data for an entire organization as a single unit. The data model quality is based on the perspectives of multiple functional areas. The single storage perspective is the focus of data value quality. Finally the quality of data representation is characterized by the various user perspectives. The perspective pertinent to each quality dimension is the basis for identifying a set of quality attributes for each dimension, as described in the next section.

Based on our literature survey, quality attributes for data values, data representations, and data models are recapped in Figure 8. Accompanying each attribute is its source(s) of reference(s) in the literature and a brief description.

Figure 7: Four data quality engineering dimensions



Absent from the presently available literature are the attributes corresponding to data architecture quality. A list of nine organizational data architecture attributes is proposed as a collection of desirable characteristics for such architectures. This list has been developed based on the experience within the Department of Defense's Center for Information Management's Information Engineering Directorate, where the second author has worked since 1992 as program manager and has participated in the development of a DOD-wide data architecture development. We propose these attributes to increase reader awareness and further discussion in this critical area. The proposed attributes are:

1. **Architectural Completeness:** The architecture is comprehensive enough to be used by any functional area of the organization wishing to utilize it.
2. **Architectural Correctness:** The information describing the architecture is correctly represented with the appropriate methodology. That is, the organization can use the methodology to maintain uniform data definitions throughout the organization.
3. **Management Utility:** The data architecture is widely used by the organization in strategic planning and systems development as an indication of its utility. In practice, architectures too often wind up as shelf-ware.
4. **Data Management Quality:** The organization as a whole is data-driven. Data models are developed and managed from an organization-wide perspective, guided by the organizational data architecture. Data are managed with distributed control from a centralized unit.

Figure 8: Recap of research contributions to the attributes of data quality

	Described By:	Larry P. English	K. Laudon	A. Levitin and T. Redman 95	C. Fox, A. Levitin, & T. Redman 94	T. Redman 92	E. Tufte	Definition
Dimension	**Attribute**							
Data	Timeliness	X					X	Data should be promptly presented to the user at the time when it is needed.
Representation	Conciseness						X	Data presented to the users match user breadth/depth requirements without data loss.
Quality	Clarity						X	Data are presented in a form that is easiest for the user to understand given the request circumstances
	Consistency					X		Data presented to the users lacks nothing with respect to the user's information requirements.
	Detail					X		Data are presented in the level of detail most appropriate for the user's need.
	Accessibility						X	Data presented to the users is free from retrieval fault, data displayed unaltered from what was stored.
	Order							Data are presented in a sequence fitting the users need and their cognitive style.
	Flexibility					X		Data are able to be easily transformed between systems, formats, media to best match user needs.
	Portibility					X		Data are able to be migrated from application to application without data loss.
	Presentation appropriateness	X					X	Data are presented in a format facilitating user comprehension.
	Media					X		Data are presented using media most effective for user comprehension.
	Unambiguousness/interpretability					X	X	Data presented to the users requires no interpretation to comprehend the correct value.
Data	Completeness	X	X		X	X		Attributes of entities requiring values have them.
Value	Correctness/accuracy	X	X		X	X		Data values maintained are free from fault, recording defects, or damage.
Quality	Currency				X	X		Data values maintained are the most up-to-date and match user expectations.
	Time Period					X		Data values maintained cover the time period required by the users.
	Clairity		X					Data values maintained match the breadth and depth of the user request parameters.
	Precision				X			Data values are maintained with the amount of precision or detail required by the user.
	Reliability				X			Data values stored can be depended upon by the user under stated conditions.
	Consistency					X		Data values continue to maintained in a steady, dependable manner.
	Timeliness				X			Data values are updated as often as the user requires.
	Relevance					X		Data values stored are directly responsive to the specific user needs.
Data Model Quality	Completeness	X						The model is comprehensive enough to be used for a reference - containing complete enough subject areas to be of use.
	Definition clarity/unambiguity	X		X		X		The model is developed and maintained according to generally accepted modeling principles indicating the modelers consistently and correctly applied the techniques.
	Relevance			X		X		The model contents represent the facts of interest to the user.
	Value obtainability			X		X		The data model is structured so that users can obtain the facts they require.
	Comprehensiveness			X		X		This quality attribute addresses the issue "Did the modelers include all of the information they desired to in the model? Is this model populated with sufficient data to be useful?"
	Essentialness			X		X		The model contains only those elements fundamentally required to describe the subject.
	Attribute granularity			X		X		The model is structured so that it maniuplates the level of detail desired by the users.
	Domain precision	X		X		X		The model maintains the factual precision desired by users.
	Naturalness			X		X		The model 'fits' with the way users assimilate facts into their work processes.
	Occurrence identifiability			X		X		The model maintains sufficient access means to uniquely identify facts requires by users.
	Robustness			X		X		Both the model component definitions and the relationships between the entities are free from interpretation-based faults.
	Flexibility			X		X		The model maintained in a fashion where it is able to be useful in multiple applications
	Minimally redundant					X		The model is implemented using minimal factual duplication to meet user needs.

5. **Data Sharing Ability:** The data architecture serves as the basis for negotiating and implementing intra-organizational data exchange agreements by anticipating, defining and managing data sharing requirements within the organization and among its business partners using organization-wide standard metadata definitions.
6. **Functional Data Quality:** Data are engineered in support of business functional area requirements where data elements for individual systems are derived from organizational metadata requirements and implemented using organizational systems designed to support information representation.
7. **Data Operation Quality:** Data quality engineering is established as a functional area actively and consistently applying data quality engineering methods to data elements.
8. **Evolvability:** The organizational data architecture is maintained in a flexible, evolving fashion to enable the fulfillment of future user requirements.
9. **Organizational Self-Awareness:** The organization demonstrates the ability to investigate architecture use and determine the types of value that it provides to end-users. Feedback helps data architects refine the architecture to make it more useful organizationally.

SUMMARY AND CONCLUSIONS

It is widely recognized that a company's data resources are vitally important for effective organizational operations. However, many organizations have experienced substantial financial losses and other negative impacts caused by imperfect data. A major reason for the problems is the lack of effective guidelines for data quality management. The problem is exacerbated by increased company dependence on computer technology for business operations and by strategic requirements necessary to improve company global competitiveness. Further adding to the problem is the trend toward systems integration within and among companies, which has forced IS departments to change focus from developing and operating relatively isolated applications to new ones capable of supporting cross-functional and interorganizational business processes.

Faced with such demands, data resources managers have received little guidance from researchers addressing the complete range of data quality dimensions they have to cope with. In order to obtain the required level of data quality, systems development efforts must consider all dimensions of data quality, including: data value, data representation, data model, and data architecture quality. Based on previous research, a more comprehensive data quality model has been proposed, as well as the attributes applicable to each quality dimension. The scope of data quality engineering should be changed from multiple triples within systems to organization-wide triple management. Data quality engineering will be more effective when also focused on rooting out structure-oriented causes of imperfect data by ensuring the quality of shared data across system boundaries with common data definitions.

Development and use of the more comprehensive data quality metadata model will enable organizations to more effectively manage those dimensions enhancing data quality. Data resources managers are encouraged to consider the expanded data life cycle model proposed here and the attributes necessary to implement an organization-wide data architecture for benchmarking purposes against their companies' presently used methodologies and data management activities.

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Chapter III

Visualizing IT Enabled Business Process Change

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Many contributions in the literature of business process change (BPC) address the questions of why and how to conduct IT enabled BPC projects. A relatively underexposed area, however, is the question of how to formulate an alternative process design. Therefore, the focus of this paper is to support BPC managers in their search for (IT enabled) alternative process design(s). The support should stem from a set of concretely defined redesign guidelines that are visualized in simple process charts. These visualized guidelines should help BPC managers to recognize their applicability in their own context. The aim of this paper is threefold. First, the literature is reviewed to formulate a number of IT enabled BPC guidelines. Second, these guidelines are visualized in process charts. Third, a case study is presented to illustrate the applicability of these visualized guidelines.

INTRODUCTION

The popular topic of business process change (BPC) has been discussed and deepened in many articles, books, workshops and conferences. For instance, the book of Sethi and King (1998) provides a collage of interesting and important papers that cover a large number of important aspects of BPC. Examples are the strategic aspects, principles and methods, expected costs and benefits, the management of BPC projects, and so forth. Sethi & King present their book as being the "third generation," since it intends to transcend the 'cheerleading' approach of numerous "BPC guru's" in previous generations (published in the 1980s and early 1990s).

The difficulty of how to organize and conduct a BPC project is reflected in the report of Revenaugh (1994). He states that about 50 to 70% of BPC projects fail: BPC projects are difficult to launch, manage and conclude successfully. Many contributors in the literature have therefore developed all sorts of BPC methodologies and techniques to support management and BPC managers to design and conduct their own BPC projects. Kettinger, Teng and Guha (1997), for instance, found that currently about 25 methodologies, 72 techniques and 102 tools exist to assist the BPC manager.

A closer look at these methodologies, techniques and tools shows that, unfortunately, the majority focuses at the questions of why and how to conduct (IT enabled) BPC projects. The basic idea of this kind of support is to indicate the steps that should be taken in a BPC project and in what particular order. Less attention is given to the question of how to formulate an alternative process design for a particular process. This notion is supported by Kettinger et al. (1997), who argue that the development of alternative process designs is a matter of "brainstorming and creativity techniques" (p. 62). We agree that this is indeed the current status of many of the available methodologies and techniques, but for a BPC manager, this is most likely a bit unsatisfactory. The manager would be really supported when the methodologies at hand would also provide assistance in his search of formulating alternative process designs.

The assistance I project provides a number of concretely defined guidelines, which are visualized in simple process charts. In this way any BPC manager should be able to recognize the implications of the guidelines, and should therefore be enforced to apply and visualize the opportunities for BPC by applying the guidelines in his or her own BPC project. These guidelines should be formulated in terms of imperatives, which ultimately, after refinement and testing, could become "precepts of BPC" (see Davenport & Stoddard, 1994, p. 126).

In this paper I want to make a contribution in the search for these BPC guidelines. This search will be focused on those guidelines that are based on IT as an enabler for BPC because IT is considered to be an important means in the redesigned process (see, for instance, Davenport & Short, 1990; Hammer, 1990; Harrington, 1991; Venkatraman, 1994; Whitman, 1996). First, the literature is reviewed to summarize recommendations, principles and opportunities for BPR into a set of five guidelines for BPC. Second, the BPC guidelines will be visualized in graphical depictions. The result of this exercise is a set of visualized redesign patterns. These patterns help BPC participants to communicate more effectively and enable a more constructive dialogue (after Barrett, 1994, p. 17). This is illustrated with a case study in the sea transportation sector.

The paper is organized as follows. An introduction to Business Process Change (BPC) is provided in the next section. Then the use of IT as enabler in BPC projects is described, followed by a discussion of how to conduct BPC projects, referred to as the methodology for BPC. Based on these insights, the literature is further reviewed in a search for IT enabled BPC guidelines, resulting in the proposal of five IT enabled BPC guidelines. These guidelines will be visualized in a case study. Finally, conclusions are drawn.

BUSINESS PROCESS CHANGE

What Is a Process?

Davenport & Short (1990) define a process as "a set of logically related tasks performed to achieve a defined business outcome" (p. 12). Curtis, Kellner and Oliver (1992) define a process more or less in the same way: "a set of partially ordered steps intended to reach a goal" (p. 75; after Feiler & Humphrey, 1992). The two definitions indicate that a process consists of a specific set of steps or tasks, which are related to each other in a specific way, to realize a predefined outcome or goal. These (process) steps or tasks can simply be defined as atomic actions that have "no externally visible substructure" (Feiler & Humphrey, 1992, p. 7).

What Is Business Process Change?

Kettinger and Grover (1995) define Business Process Change as "a strategy driven organizational initiative to improve and (re)design business processes to achieve competitive advantage in performance (e.g., quality, responsiveness, cost, flexibility, satisfaction, shareholder value, and other critical process measures) through changes in the relationships between management, information technology, organizational structure, and people" (p. 12).

Why Change Business Processes?

The driving forces for initiating BPC projects are concisely summarized by Hammer and Champy (1993) into three *Cs*. First, there are the customers, which "take charge" and "demand for products and services designed for their unique and particular needs" (Hammer & Champy, 1993, p. 18). A second driver is the competition, which continuously intensifies. This both asks for the increase (internal) of efficiency as well as the optimization of the fit between customer requirements and (internal) capabilities (see also the first *C*). The third *C* is of change, which becomes constant, while the pace of change accelerates. An analysis of these three forces, separately and in combination, should foster the organization's managers to rethink and redesign current business processes.

IT ENABLED BUSINESS PROCESS CHANGE

It is widely claimed that IT plays a crucial role in conducting a successful BPC project. The capacities of IT to store, process and exchange information quickly and relatively inexpensively (Huber, 1990) make it an interesting enabler for changing business processes. Davenport (1993) describes IT as the lever for performance improvement in the IT-process-productivity relationship (see Figure 1). The IT initiative results in a change of business process(es) and this change should lead to performance improvement.

Davenport and Short (1990) identify nine capabilities of IT to change processes. These capabilities are summarized and explained in Table 1.

Figure 1: The IT-process-productivity relationship (adapted from Davenport 1993, p. 45)

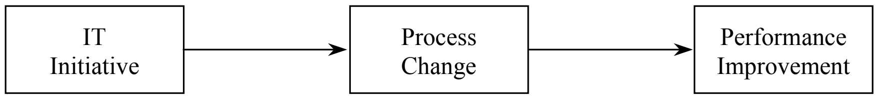


Table 1: Capabilities of IT (Davenport & Short, 1990)

- Transactional: IT can transform unstructured processes into routinized transactions
- Geographical: IT can transfer information rapidly and with ease across large distances, making processes independent of geography
- Automational: IT can replace or reduce human labor in a process
- Analytical: IT can bring complex analytical methods to bear on a process
- Informational: IT can bring vast amounts of detailed information into a process
- Sequential: IT can enable changes in the sequence of tasks in a process, often allowing multiple tasks to be worked on simultaneously
- Knowledge management: IT allows the capture and dissemination of knowledge and expertise to improve the process
- Tracking: IT allows the detailed tracking of task status, inputs, and outputs
- Disintermediation: IT can be used to connect two parties within a process that would otherwise communicate through an intermediary (internal or external)

Levels of IT Integration in BPC

Venkatraman (1994) distinguishes five levels of IT integration in BPC, which are: (1) localized exploitation, i.e., the use of IT within departments; (2) internal integration, i.e., the use of IT to integrate localized IT use across the organization; (3) business process redesign, i.e., the use of IT to transform business processes; (4) business network redesign, i.e., the use of IT to redesign processes and roles of organizations within a business network; and (5) business scope redefinition, i.e., the use of IT to realize new ways of doing business. The higher levels correspond to a higher degree of required business transformation and will cover a higher range of benefits.

In this paper, Venkatraman's framework is simplified into three main levels of IT integration. The first level of IT integration is called business process automation (BPA). BPA initiatives use IT to automate a (set of) process(es) to improve its performance without altering its current design. The second level of BPC is business process redesign (BPR). BPR initiatives aim to formulate alternative designs for a specific (set of) process(es) to improve its performance. In the literature BPR initiatives have been termed differently, such as business process reengineering

(Hammer, 1990), business process innovation (Davenport, 1993), and core process redesign (Kaplan & Murdock, 1991). The third level is called business network redesign (BNR). This third level is a logically next step after BPR. In a BPR project primary attention is given to internal processes, while at the BNR level one intends to focus at the internal processes in relationship to the processes of external partners. Clark and Stoddard (1996) call this interorganizational business process redesign. In these cross-boundary types of BPC projects the focus is at issues such as to automate and/or redesign interorganizational processes (like the exchange of information) and to reallocate particular process steps among participating business partners. In this respect BNR refers to the concept of outsourcing. Outsourcing "can be a key element of BPR since it essentially involves a decision to have someone else perform certain activities or tasks in a business process" (Sethi & King, 1998, p. 241). Strategically outsourcing may emphasize the organization's core competencies to achieve a maintainable competitive edge, a decrease in transaction costs, a decrease in vulnerability, an increase in sourcing control, and/or an increase in flexibility (see also Quinn & Hilmer, 1994). Especially the effects of IT on transaction costs and therefore on the optimal division of activities among business partners have been frequently discussed (see, for an overview, Klein, 1996). Inspired by the transaction cost economics approach of Williamson (1975, 1985), Clemons, Reddi and Row (1993) argue to compare the costs of internal production versus the costs of external production plus transaction costs before an IT investment proposal is implemented and after the implementation. Based on this comparison, activities should be insourced or outsourced. Or, as Jarillo and Stevenson (1991) describe it: "At each step of the value chain of the company, it has ... [to make] ... a conscious choice as to whether that step should be performed inside or outside, seeking always maximum efficiency in the attainment of its strategic goals, and devising ways to reduce the problems that each decision entails" (p. 67).

BPC METHODOLOGIES

Many methodologies have been proposed in the literature to answer the question of how to conduct a BPC project. An interesting and comprehensive methodology is proposed by Kettinger et al. (1997). Their methodology, called the Stages-Activities (SA) Framework, is based on the analysis of 25 different methodologies. The SA Framework consists of 6 stages which are further broken down into 21 activities (see Figure 2). Stage 1 is called envision: management should recognize the need for BPC and should identify reengineering opportunities. Second, the BPC project should be initiated, followed by Stage 3, in which the current process design is diagnosed. Stage 4 concerns the redesign of the process(es). Stage 5 is the reconstruction of the organization's structure, and in Stage 6 the BPC project is evaluated. Besides the 25 methodologies, Kettinger et al. (1997) also identified 72 techniques and 102 tools that all support (parts of) the stages and activities of the SA Framework. They provide an overview of which particular technique or tool supports a specific stage or activity.

Three activities in this framework comprise the formulation of alternative process designs: discover reengineering opportunities (S_1A_2), identify IT levers (S_1A_3) and define and analyze new process concepts (S_4A_1). From Kettinger et al.'s analysis, it appears that only one single technique supports all three activities, and that is the technique of brainstorming. Brainstorming is a technique to foster creativity by withholding evaluation until a number of ideas have been generated. Many other creativity enhancement techniques exist to determine reengineering opportunities (see, for an overview, Couger, Flynn and Hellyer, 1994).

Indeed creativity techniques may support BPC managers to formulate alternative process designs, but in this paper I am looking for more formal support in terms of concrete BPC guidelines. A BPC guideline is a general statement (imperative) of how to formulate an alternative process design.

IN SEARCH FOR BPC GUIDELINES

The subset of contributions in the literature that provide hints or clues for the BPC manager of how to formulate alternative process designs vary from less concretely defined recommendations to more concretely defined guidelines.

Recommendations for BPC

Recommendations have been provided by many authors (see, for instance, the special issue of *Journal of Management Information Systems* in 1995, with contributions of Kettinger & Grover, 1995, and Stoddard & Jarvenpaa, 1995, but also Bashein, Markus & Riley, 1994; Hammer & Champy, 1993; Kettinger, Guha & Teng, 1995; Mayer, Benjamin, Caraway & Painter, 1995; Smith, McKeen & Nelson, 1995; Talwar, 1993). Frequently proposed recommendations are listed in Table 2. Though such recommendations might be useful, especially regarding the initiating phase of a BPC project, see first two stages of the SA Framework of Kettinger et al. (1997), they both lack focus and specificity when it comes to formulating the BPC guidelines.

Figure 2: SA framework (Kettinger et al., 1997)

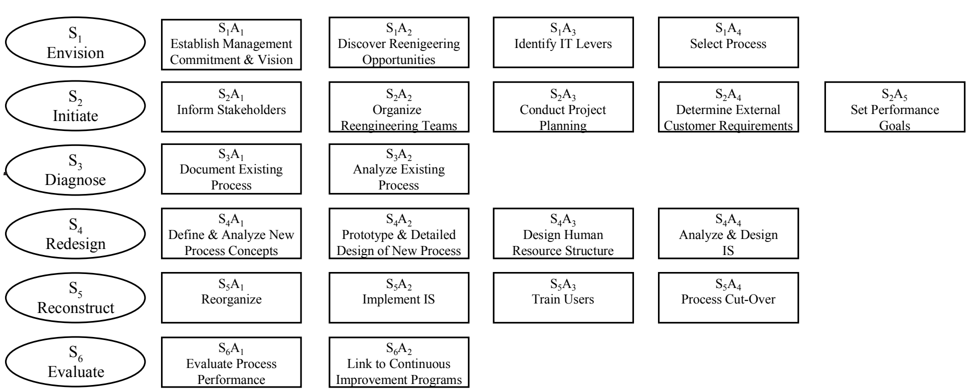


Table 2: List of frequently discussed recommendations for BPC projects

	Stoddard & Jarvenpaa 1995	Kettinger & Grover 1995	Bashein et al. 1994	Talwar 1993	Kettinger et al. 1995	Hammer & Champy 1993	Mayer et al. 1995	Smith et al. 1995
Use IT as enabler		•		•	•			•
Acquire top management support		•	•			•	•	
Embed the BPC project in organization's strategy		•	•		•			
Check readiness of organization		•						
Challenge current organizational principles		•		•		•		•
Use BPC methodologies and techniques		•						
Empower employees		•	•					•
Radical versus incremental improvement	•	•	•			•		
Set (audacious) objectives				•	•	•	•	
Simplify and annihilate				•			•	
Rethink functions and processes				•		•	•	
Create a customer focus		•		•			•	

From Recommendations to Guidelines

The recommendations made by Teng, Grover and Fiedler (1994) are a bit more specific. They have conceptualized two characteristics of a business process to illustrate options for IT enabled redesign. The characteristics are degree of mediation and degree of collaboration. The degree of mediation refers to the degree of the tasks of a process being performed sequentially or simultaneously. The higher the degree of mediation, the larger the number of tasks being performed in a sequence. The degree of collaboration refers to what extent information is exchanged among tasks. Four general process patterns can be identified: low mediation/low collaboration, high mediation/low collaboration, low mediation/high collaboration, and high mediation/high collaboration. In this matrix, Teng et al. (1994) have formulated five strategic paths for IT enabled redesign: increase degree of collaboration (with either low or high mediation), decrease degree of mediation (with either low or high collaboration), and increase degree of collaboration in combination with a decrease in the degree of mediation. Depending on the current design of a process, one of these paths might be of interest to redesign the process to improve its performance. For instance, the last path that combines the aim for a high collaboration and a low mediation is suitable for knowledge-intensive managerial processes which are now designed with many sequential input-output flows.

Even more specific than Teng et al. are the contributions of Stalk and Hout (1990) and Hammer (1990). They try to come up with concrete guidelines for IT enabled BPC. Stalk and Hout (1990) advocate concentrating on the "main sequence" of activities. These are the activities that directly add value to the customer in real time (see also Selander & Cross, 1999). This is in line with the idea that BPC projects should be focussed on 'core processes' (Kaplan & Murdock, 1991). The argument of Stalk & Hout is that organizations which compete on time identify direct adding value activities, isolate them from support activities and organize them in a clear and consistence sequence.

The other contribution is of Hammer (1990), who has proposed seven reengineering principles (See Table 3), which fit our definition of a BPC guideline. Some of these guidelines focus on functional aspects (like the first one: organize around outcomes not tasks), while others explicitly focus on the redesign of processes (like the fifth one: link parallel activities instead of integrating their results). In this paper I am mainly interested in the second type of guidelines.

The Proposal for IT Enabled BPC Guidelines

Based on the findings in the literature, I now propose a preliminary set of five IT enabled BPC guidelines (see, for an initial proposal, Hoogeweegen, 1997). The guidelines are classified into the three levels of IT integration (two guidelines for BPA, two for BPR and one for BNR).

Guideline 1: Automate Information Storage and Processing Tasks (BPA Level)

This guideline refers to the BPA level of integration. The guideline is based on the "analytical" and "automational" capabilities of IT (see Davenport & Short, 1990) and refers to the principle of Hammer (1990) to "capture information once and at the source," and "subsume information-processing work into the real work that produces the information." By doing this, tasks and/or processes will be simplified or even annihilated (see one of the mentioned recommendations in Table 2). The projected result of applying this guideline is to increase efficiency of a process.

Table 3: Reengineering principles of Hammer (1990)

- Organize around outcomes not tasks
- Have those who use the output of the process perform the process
- Subsume information-processing work into the real work that produces the information
- Treat geographically dispersed resources as though they were centralized
- Link parallel activities instead of integrating their results
- Put the decision point where the work is performed, and build control into the process
- Capture information once and at the source

Guideline 2: Automate Information Exchange Tasks (BPA)

This guideline also belongs to the BPA level and is based on the "transactional" and "geographical" capabilities of IT. The use of IT as described by the geographical capability supports the principle of Hammer (1990) to "treat geographically dispersed resources as though they were centralized." Analogous to the first guideline, the projected result of applying this guideline is to increase efficiency of a process.

Guideline 3: Execute Tasks Simultaneously (BPR)

This guideline, which belongs to the BPR level, states that the current relationships between tasks should be reconsidered: is it possible, using for instance, the "sequence" capability of IT, to process these tasks simultaneously instead of in a sequence? The projected result of applying this guideline is to decrease throughput time of a process.

Guideline 4: Improve Planning Tasks (BPR)

This is the second guideline that belongs to the BPR level. The guideline is based on the "tracking," "informational" and "knowledge management" capabilities of IT. The guideline refers to the timely forwarding of information to planning processes. Analogous to the previous guideline, applying this guideline should result in the reduction of throughput time.

Guideline 5: Consider Outsourcing or Reallocation of Tasks and Processes (BNR)

The last guideline belongs to the BNR level of IT integration. It refers to the discussion whether to outsource particular tasks and/or processes. The use of IT within an interorganizational setting, like electronic data interchange (EDI), might change the level of production costs, coordination costs and transaction risks (see Clemons et al., 1993). Therefore, new divisions of activities among the participants in the interorganizational setting might lead to a lower level of costs and risks. In the end, some participants may even become redundant (see "disintermediation" capacity of IT).

VISUALIZATION OF IT ENABLED REDESIGN GUIDELINES

In this section the five guidelines will be visualized in process charts with a simple diagramming technique. The visualized guidelines may help BPC managers to recognize these process patterns in their own organizations (see also, for instance, Guimaraes, 1999; Selander & Cross, 1999). The graphical nature of diagramming techniques makes them easy to use and easy to understand. Processes are visualized in the simplest graphical depictions, which, as Barrett (1994) argues "succinctly focus on the key elements of the process and show how they interact" (p. 18). Barrett describes the importance of process visualization in BPR projects, which he defines as "to have a mental picture of the future reengineered business process in advance of its realization" (p. 15).

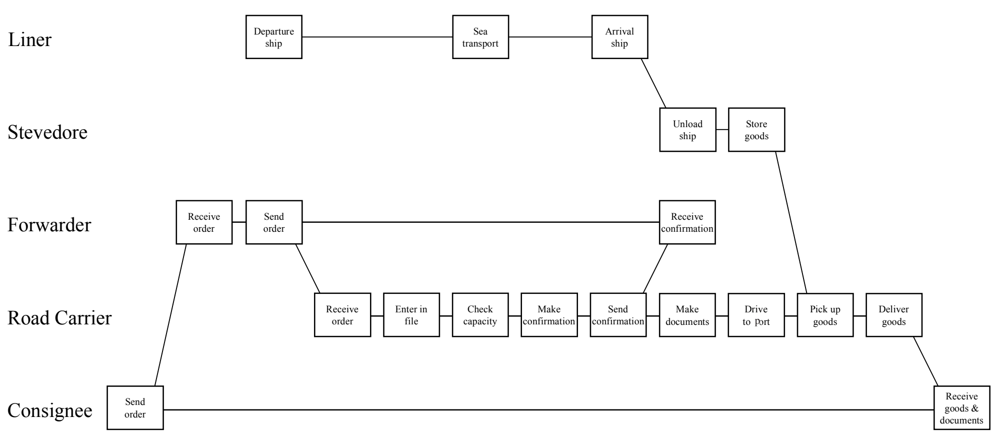
The process diagrams to be constructed in this section are based on four simple rules. One, parties involved in the modeled processes are depicted vertically; elapsed time is depicted horizontally. Two, current process steps (referring to the steps that are currently part of the process) are depicted in white boxes. Three, removed (or erased) process steps are covered by a black cross. Four, new process steps are depicted as hexagonal boxes.

The examples are based on a case study conducted at a road carrier, primarily active in the Port of Rotterdam community. Like its competitors this road carrier is faced with the continuous eroding of margins. Therefore, management is looking for ways to increase current efficiency rates of its head department. One alternative is the search for ways to streamline internal processes, preferably in such a way that even the customer is better served (for instance, by lowering its lead time). The processes performed and managed by this head department are "order processing" and "shipping and distribution." Grover, Fiedler and Tang (1999) show that these processes are frequently the subject of BPC projects (in their study these processes were mentioned by 13% and 4%, respectively, out of a sample of 219 respondents as being redesigned in their BPC projects). The five identified guidelines will now be applied to illustrate how this road carrier could streamline these processes.

Current Process Design

The current process design regarding the pickup of a shipment in the Port of Rotterdam and the delivery of this shipment at a consignee is depicted in Figure 3. This figure only depicts those steps belonging to the "main sequence" as meant by Stalk and Hout (1990). The process steps to be taken by the road carrier are placed in the context of the steps to be taken by its business partners.

Figure 3: Current process design



The main process is as follows. A consignee asks a forwarder to arrange all aspects of the delivery of its shipment from the port to its own place. The forwarder will, among other things, arrange road transportation by sending our road carrier a transportation order. The road carrier will check whether there is a truck available and, if so, will send a confirmation to the forwarder. Meanwhile, the vessel that contains the focal shipment is approaching the Port of Rotterdam. The stevedore will unload the vessel after arrival and it will store the shipment till the truck of our road carrier arrives. The road carrier will prepare all necessary road transportation documents (like consignment note bill and customs declaration forms) and will drive with its truck to the stevedore. After picking up the shipment, it will deliver both the shipment and the documents at the consignee.

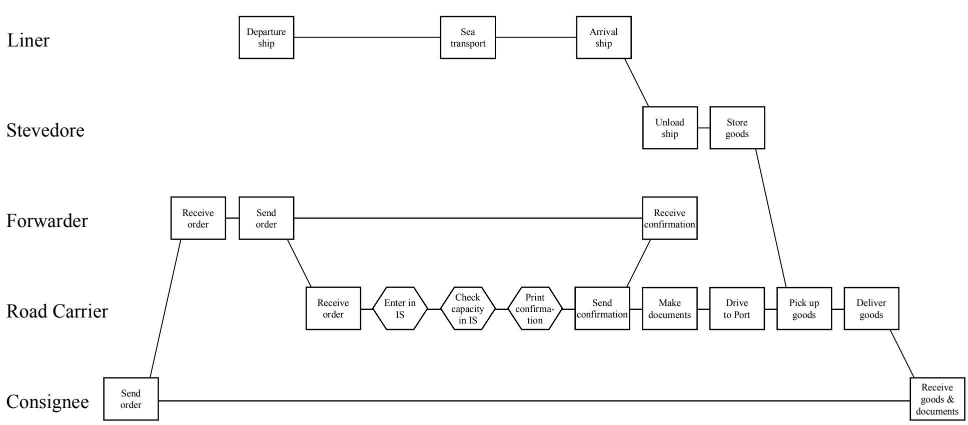
Applying the First BPC Guideline

Figure 3 is the basis for our effort to apply the five redesign guidelines to streamline the current process design. The first guideline advocates automating information storage and processing tasks. The road carrier could automate the process of filing the incoming transportation order, the checking of available capacity and the preparing of a confirmation. Figure 4 shows how these three steps can be replaced by three new steps based on the use of an information system (IS). By entering the transportation order in the IS, the capacity can be checked automatically by the IS, followed by printing a confirmation directly from the IS. The automated process will probably reduce operating costs and maybe also reduce throughput time.

Applying the Second BPC Guideline

The process design depicted in Figure 4 can be further automated by applying the second guideline: automating information exchange. The result is depicted in Figure 5. In case of the use of EDI for the information exchange tasks, two tasks become redundant. First, entering the order in the IS will

Figure 4: A redesign proposal based on the first guideline



proceed automatically when the EDI order has been received; second, printing a confirmation is not needed anymore since the internal IS will send an EDI confirmation automatically to the forwarder.

Applying the Third BPC Guideline

Based on the suggestions made in Figures 4 and 5, a new process design can be constructed (see Figure 6). Based on this new design, the road carrier considers how further streamline the process by trying to execute two important tasks simultaneously (third guideline). These two tasks are the preparation of the documents and the physical transportation of the shipment from stevedore to consignee.

A consequence of the simultaneous execution of these tasks is that the documents have to be sent by fax or EDI to the consignee. As a result a new task is required to implement this third guideline: the sending of the documents by the road carrier to the consignee (see Figure 7).

Figure 5: A redesign proposal based on the second guideline

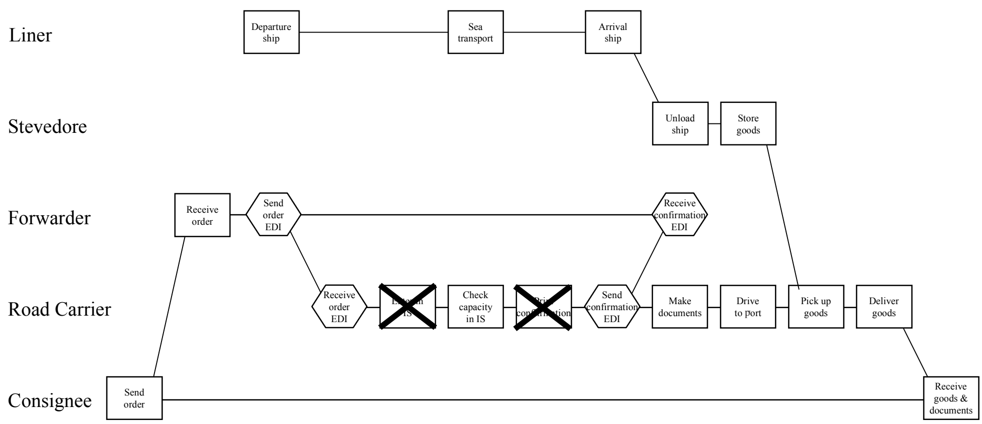
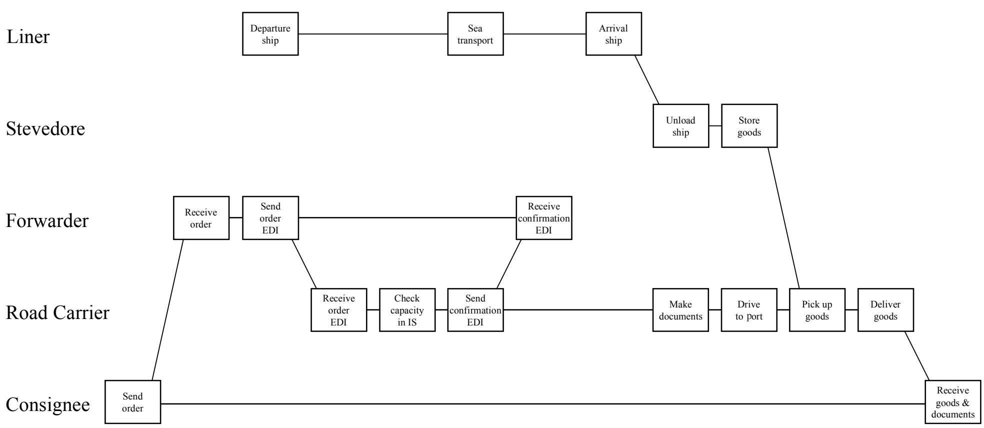


Figure 6: New process design–based on effectuation of Guidelines 1 and 2



Applying the Fourth BPC Guideline

A further reduction in lead time as well as the total costs made for the shipment, could stem from a better planning procedure. The need for storing the goods at the stevedore could be canceled out by letting the road carrier exactly know what time the vessel will be unloaded. This could be accomplished by sending a pre-arrival notification (PAN) message to the road carrier. In this example, the liner will send such a message to the forwarder (since the liner will probably not know who is responsible for road transportation), who will forward it directly to the road carrier. The road carrier can now proceed with planning the road transportation seamlessly to the expected time on unloading the vessel. This example of applying the fourth guideline is depicted in Figure 8.

The two proposals of Figures 7 and 8 are effectuated into a new process design (see Figure 9).

Figure 7: A redesign proposal based on the third guideline

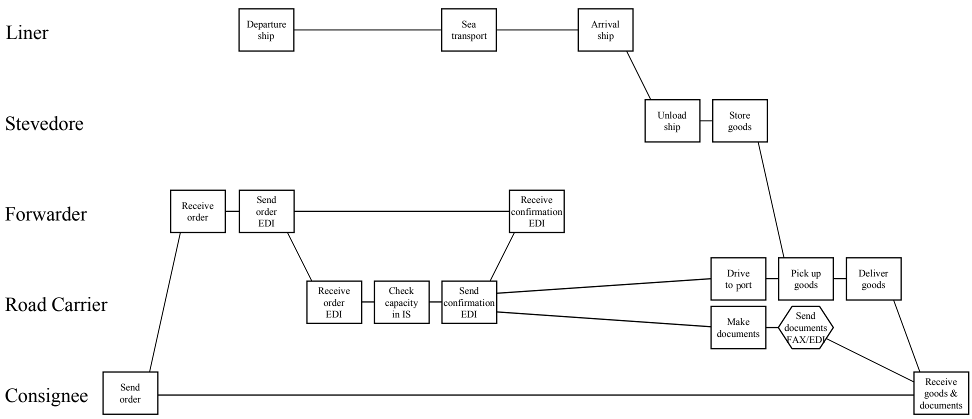


Figure 8: A redesign proposal based on the fourth guideline

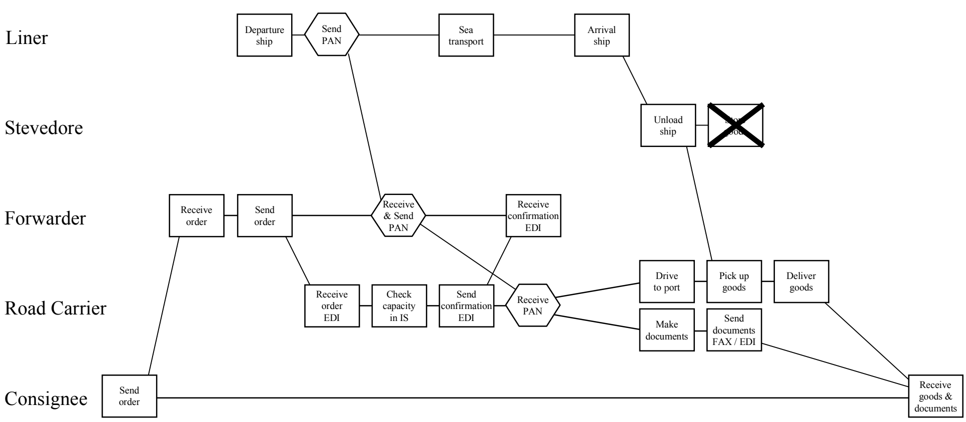


Figure 9: New process design - based on effectuation of Guidelines 3 and 4

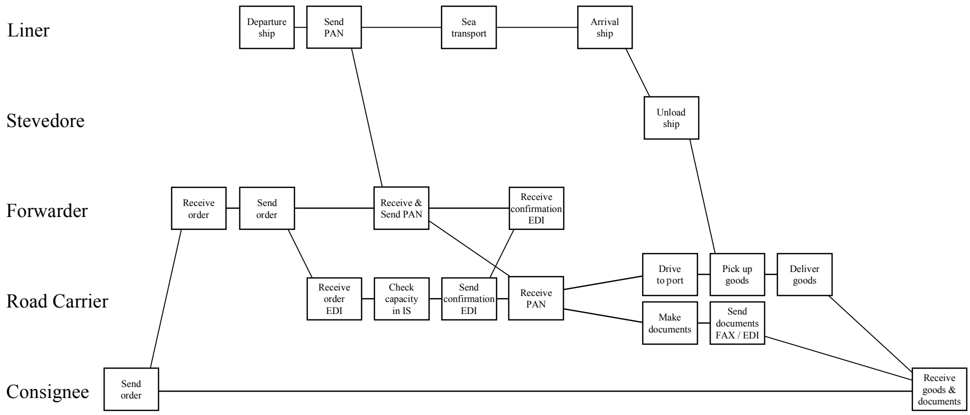
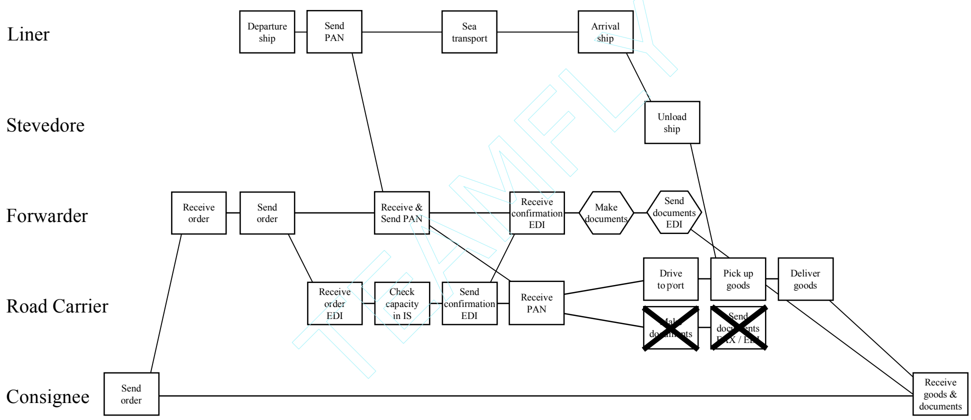


Figure 10: A redesign proposal based on the fifth guideline, first option



Applying the Fifth BPC Guideline

Now that the ordering process has been simplified and the delivery process (in terms of preparing documents and delivering the shipment) accelerated, the road carrier reconsiders how to further streamline the total chain of activities in this network. The fifth guideline encourages the reallocation of activities among network partners to improve the service offered to the consignee. At least two options are available to the road carrier. First it can consider relieving its own head department by letting the forwarder prepare the necessary documents (outsourcing). This option is depicted in Figure 10.

The other option, to the contrary, considers the disintermediation of the forwarder by directly taking the transport order from the consignee and directly receiving the PAN message from the liner (see Figure 11). This option is difficult to implement. First the forwarder will not cooperate with its own disintermediation. Second, the liner has to be informed to whom to send the PAN.

When the second option could be effectuated, the road carrier could start again to apply Guidelines 1 and 2, now in cooperation with the consignee. Ultimately, a final new process design would then look like that illustrated in Figure 12.

Based on this exercise of applying the (visualized) guidelines in its own context, the road carrier understood how to benefit from the opportunities of IT to redesign internal processes, both to increase efficiency and to increase customer service by reducing lead time. This activity of diagnosing the current design and formulating alternative designs is the heart of the SA Framework of Kettinger et al. (1997; see Stages 3 and 4). It is now up to the road carrier to proceed with Stages 5 and 6, i.e., the reconstruction of the newly defined organization's structure and the evaluation of the BPC project.

Figure 11: A redesign proposal based on the fifth guideline, second option

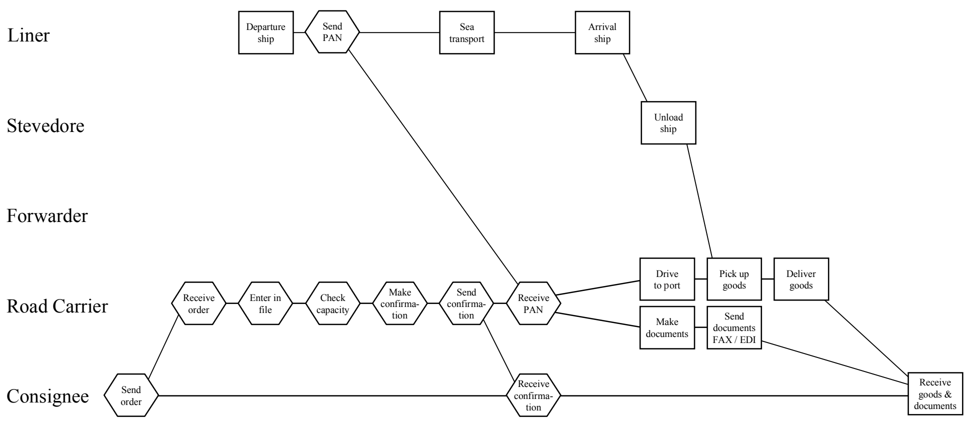
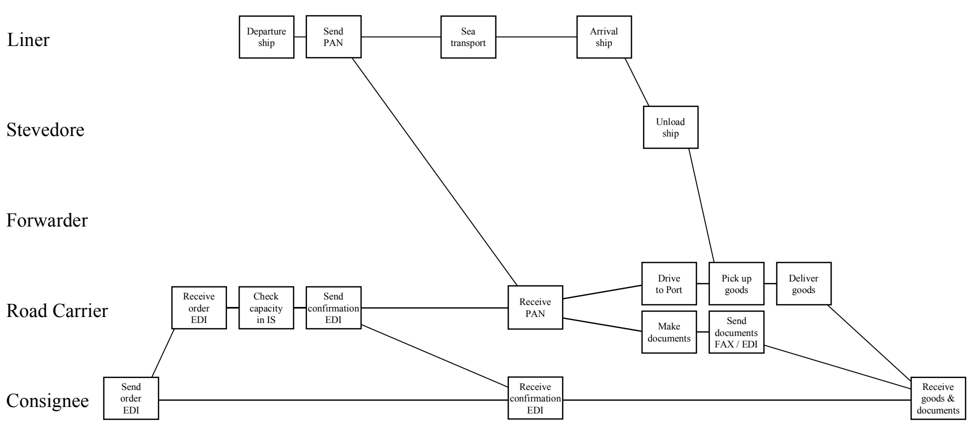


Figure 12: Final picture of the redesigned business processes of the road carrier



SUMMARY

In BPC literature many methodologies and techniques are presented to assist the BPC manager in the organization and execution of BPC projects. Unfortunately, one of the most important steps in a BPC project is often underexposed in these methodologies. That is the step of the formulation of an alternative design of a particular process that is under redesign consideration. It is obvious that this step is highly context dependent, but the BPC manager would be helped with some directly applicable BPC guidelines instead of the frequently provided advice to brainstorm and to use creativity techniques.

In this paper I have tried to come up with a number of IT enabled BPC guidelines. In the literature I have searched for these types of guidelines. Many of the guidelines found do not transcend the level of generic recommendations. The most concrete and directly applicable guidelines have been selected and presented in diagrams. By visualizing the guidelines in diagrams, concrete patterns of how to redesign processes emerge. BPC managers can use these patterns to recognize redesignable processes within their own organizations.

The strategy to visualize IT enabled BPC guidelines should be further refined and tested in practice to design a concise set of guidelines that together form the "precepts" of conducting BPC projects. The further search for this concise set in the coming years may then become the "fourth generation" of BPC literature.

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Chapter IV

Relating IS Infrastructure to Core Competencies and Competitive Advantage

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The value of information technology (IT) in today's organizations is constantly debated. Researchers and practitioners have examined organizations to try to discover causal links between competitive advantage and IT. This paper presents and details a model that depicts a possible connection between competitive advantage and IT. Furthermore, this paper attempts to show how one major component of the overall IT resources, the information systems (IS) infrastructure, might yield sustained competitive advantage for an organization. More precisely, IS infrastructure flexibility is examined as an enabler of "core competencies" that have been closely related to sustained competitive advantage in the research literature. The core competencies enabled by IT that are the focus of this study are mass customization and time-to-market. By showing that IS infrastructure flexibility acts as an enabler of these competencies, the relationship to sustained competitive advantage is demonstrated.

INTRODUCTION

A fiercely competitive business environment is an omnipresent reality in many commercial industries today. Forces such as global competition, ever changing consumer attitudes, rapidly decreasing cycles of technological innovations, social and cultural upheavals, and instantaneous access to widespread information have been catalysts of this competitive climate. These competitive pressures have prompted business organizations in virtually every industry to institute radical organizational initiatives and mandates to do battle among themselves. In recent years, senior management in large and small organizations has tried many different maneuvers such as total quality management (Choi & Behling, 1997), reengineering (Hammer, 1990; Hammer & Champy, 1993), downsizing (Robbins & Pearce, 1992), rightsizing (Zeffane & Mayo, 1994), and flattening organizational structures (Daft & Lewin, 1993; Heydebrand, 1989) to stay competitive or to gain a sustained competitive advantage.

Many researchers and practitioners have advocated using information technology (IT) as a source of competitive advantage (Benjamin, Rockart, & Scott Morton, 1984; Clemons, 1986, 1991; Feeny, 1988; King, Grover, & Hufnagel, 1989; Neo, 1988; Parsons, 1983; Porter & Millar, 1985). Companies such as Wal-Mart, American Airlines, and Baxter International have been cited as corporations that gained sustained competitive advantage from IT. This paper investigates this concept of IT being an agent of competitive advantage and attempts to show how one major component of the overall IT resource, information systems (IS) infrastructure flexibility, might yield sustained competitive advantage for a firm. More precisely, IS infrastructure flexibility is examined through its relationships as an enabler of core competencies that have been closely linked to sustained competitive advantage in the management literature. The core competencies that are closed linked here with IS infrastructure flexibility are mass customization and time-to-market.

At one time, the competitive value of IT was thought to come from so-called strategic information systems (SISs) (Reich & Benbasat, 1990; Sabherwal & King, 1995; Sabherwal & Tsoumpas, 1993; Wiseman, 1988). SISs change the goals, operations, products, or environmental relationships of organizations to help them gain an advantage, at least temporarily, over other companies in their industry (Wiseman, 1988). During the 1980s and early 1990s, strategic systems like American Airlines' Sabre System (Hopper, 1990), Digital Equipment Corporation's XCON (Sviokla, 1990), Federal Express's tracking and sorting system (Stahl, 1995), and Baxter's International ASAP system (Scott, 1988) were popular. Many companies were desperately trying to develop their own SISs to win customers and market share.

However, some recent research evidence has cast doubt on the ability of SISs to sustain competitive advantage for their companies. Mata, Fuerst, and Barney (1995) reasoned that proprietary technologies like SISs are becoming increasingly difficult to keep proprietary. They noted that a wide variety of factors–workforce mobility, reverse engineering, and formal and informal technical communications–are present to disseminate detailed information about proprietary technology like SISs. Kettinger, Grover, Subashish, and Segars (1994) provided evidence that companies implementing SISs typically did not maintain their competitive advantage over time without other factors being present. In their study, they uncovered information that the preexistence of unique structural characteristics is an important determinant of SISs' outcomes, that is, whether they provide sustained competitive advantage or not. Neumann (1994) also rationalized that SISs need complementary assets to lead to sustained competitive advantage. Without such interrelated assets, he demonstrated that any technology can be easily imitated, thus losing its competitive advantage.

In studying the research on the ability of SISs to maintain a competitive edge, one theme seems to permeate throughout. Focus always falls on the importance of the technical foundations of the firms implementing SISs. Capabilities like "unique structural characteristics" (Kettinger et al., 1994), "complementary assets" (Neumann, 1994), "managerial IT skills" (Mata et al., 1995), and "structural differences" (Clemons & Row, 1991) are nearly always used in connection with the ability of SISs to maintain competitive advantage. Kettinger and his colleagues (1994) discovered that one of these structural capabilities that seemed to make a difference was the technological platform, or infrastructure. Davenport and Linder (1994) also stated that the success of the few companies with SISs really was derived from long-term, well-planned investments in networks, databases, and applications rather than ingenious individual applications. These networks, databases, and applications are components of an organizational IS infrastructure (Byrd & Turner, 2000; Duncan, 1995). In light of all these discoveries, researchers now emphasize that the search for competitive advantage from IT has shifted from SISs to the strategic value of IS infrastructure (Davenport & Linder, 1994).

Researchers and practitioners alike have taken note of the potential value of an organization's IS infrastructure. In fact, the growing strategic value of the IS infrastructure is almost undeniable. IS infrastructure expenditures account for over 58% of an organization's IT budget, and the percentage is growing at 11% a year (Broadbent & Weill, 1997). Some even have called IS infrastructure the new competitive weapon and see it as being crucial in developing sustained competitive advantage (Boar, 1993, 1997; Davenport & Linder, 1994). Rockart, Earl and Ross (1996) reflect the ideal goals of an IS infrastructure in stating:

> … an IS infrastructure of telecommunications, computers, software, and data that is integrated and interconnected so that all type of information can be expeditiously–and effortlessly, from the user's viewpoint–routed through the network and redesigned processes. Because it involves fewer manual or complex computer-based interventions, a "seamless" infrastructure is cheaper to operate than independent, divisional infrastructures. In addition, an effective infrastructure is a prerequisite for doing business globally, where the sharing of information and knowledge throughout the organization is increasingly vital.

From these statements, the strategic value of the IS infrastructure seems to be growing.

McKay and Brockway (1989) called IS infrastructure the enabling foundation of shared IT capabilities upon which the entire business depends. Weill (1993) also noted that IS infrastructure was a foundation for capability across business units or functional units. Davenport and Linder (1994) referred to IS infrastructure as that part of the organization's information capacity intended to be shared among all departments. They concluded that an IS infrastructure is a firm's institutionalized

IT practice–the consistent foundation on which the specific business activities and computer applications are built. Congruent with these others, Duncan (1995) described IT infrastructure as a set of shared, tangible IT resources forming a foundation for business applications. The tangible IT resources composing an IS infrastructure are platform technology (hardware and operating systems), network and telecommunication technologies, data, and core software applications (Byrd & Turner, 2001; Duncan, 1995).

As indicated by these statements, an IS infrastructure is the keystone for the development of business applications and the backbone for electronic communications in an organization. It also follows that the development of an IS infrastructure is arguably the most important aspect of managing IT resources in an organization. Based on the above definitions and descriptions from the literature, IS infrastructure in this study is defined in this paper as follows:

> IS infrastructure is the shared IT resources of hardware, software, communication technologies, data, and core applications that provide a unique technological foundation (1) for widespread communications interchanges across an organization and (2) for the design, development, implementation, and maintenance of present and future business applications.

Unique characteristics of an IS infrastructure determine the value of that infrastructure to an organization. Duncan (1995) wrote, "One firm's infrastructures may make strategic innovations in business processes feasible, while the characteristics of competitors' infrastructure may likewise cause their inability to imitate the innovation rapidly enough to mitigate the first mover's advantage. This set of characteristics has been loosely described as infrastructure 'flexibility'" (p. 38). It is this characteristic of IS infrastructure that has captured much of the attention of researchers and practitioners. In fact, in most recent surveys featuring the issues most important to IT executives, the development a flexible and responsive IS infrastructure and related topics are always at or near the top of the responses (Boar, 1997; Brancheau, Janz & Wetherbe, 1996; Niederman, Brancheau, & Wetherbe, 1991).

FLEXIBILITY

Flexibility is emerging as a key competitive priority in many organizational activities such as manufacturing (Gupta & Somers, 1992; Ramasesh & Jayakumar, 1991), high technology maneuvers (Evans, 1991), automation (Adler, 1988), and finance (Mason, 1986). Researchers also have heralded the competitive benefits of overall organizational flexibility (Aaker & Mascarenhas, 1984; De Leeuw & Volberda, 1996; Krijnen, 1979).

Flexibility in the management literature is defined as "the degree to which an organization possesses a variety of actual and potential procedures, and the rapidity by which it can implement these procedures to increase the control capability of the management and improve the controllability of the organization over its environment" (De Leeuw & Volberda, 1996, p. 131). Flexibility, therefore, gives an organization the ability to control outside environments effectively. For example, high flexibility corresponds to high managerial control of the organization with respect to the environment (De Leeuw & Volberda). The more control an organization has over its competitive environment, the better its competitive position. Control is any manner of directed influence. The environment is an external force that can dictate patterns in actions either through direct imposition or through implicitly preempting organizational choice.

Flexibility is related to terms like adaptability, versatility, agility, elasticity, and resiliency (Evans, 1991). Organizations with high flexibility in key areas should be able to respond very quickly to strategic moves by competitors (Boar, 1997). These organizations should also be adept at initiating strategic moves of their own in attempts to gain competitive advantage over their competitors. The research literature cited has acknowledged the importance of flexibility of key components of an organization. The implication of this literature is that flexibility of these key components is so very valuable in today's competitive environment. The IS infrastructure as discussed above is certainly one of the key components of an organization (Armstrong & Sambamurthy, 1999; Byrd & Turner, 2000, 2001; Davenport & Linder, 1994; Duncan, 1995; Rockart et al., 1996). Therefore, the investigation of IS infrastructure flexibility is assuredly a worthwhile study.

IS Infrastructure Flexibility

Flexibility as it applies to IS infrastructure means the abilities of the infrastructure to support a wide variety of hardware, software, and other technologies that can be easily diffused into the overall technological platform, to distribute any type of information–data, text, voice, images, video–to anywhere inside of an organization and beyond, and to support the design, development, and implementation of a heterogeneity of business applications. These properties of an IS infrastructure help give management control over the external environment. For example, if an IS infrastructure supports a wide variety of hardware or software, the organization can more easily cope with changes in hardware or software industry standards. In the same way, if a technology platform can support the distribution of most types of data, new data like images and voice can more easily be distributed from one division of the company to another division.

The study of IS infrastructure is still in its infancy with only a few studies (e.g., Broadbent & Weill, 1997; Duncan, 1995; Weill, 1993). One of these has demonstrated one way to describe IS infrastructure flexibility more precisely with the qualities of connectivity, compatibility, and modularity (Byrd & Turner, 2000; Duncan, 1995). Connectivity is the ability of any technology component to attach to any of the other components inside and outside the organizational environment. According to Keen (1991), connectivity–which he calls "reach"–"determines the locations the platform can link, from local workstations and computers within the same department to customers and suppliers domestically, to international locations, or … to anyone, anywhere" (p. 39). Compatibility is the ability to share any type of information across any technology components. At one extreme of range, only simple text messages can be shared, while at the other extreme, any document, process, service, video, image, text, audio, or a combination of these can be used by any other system, regardless of manufacturer, make, or type.

Modularity is the ability to add, modify, and remove any software or hardware components of the infrastructure with ease and with no major overall effect. Modularity relates to the degree to which IT software, hardware, and data can be either seamlessly and effortlessly diffused into the infrastructure or easily supported by the infrastructure. It defines the options available to alter the configurations of hardware, software, telecommunications, and data. Issues surrounding the concept of modularity are portability, scalability, interoperability and openness.

An organization with high connectivity, compatibility, and modularity is viewed as having high IS infrastructure flexibility. A company using technologies with high connectivity, compatibility, and modularity, i.e, high flexibility, has the potential to quickly move its IS infrastructure to match many different changes in directions of the strategy and structure of the organization. In the competitive environment of today, such agility or versatility is almost a necessity to defend against rival firms.

Tapscott and Caston (1993) argued persuasively that a technology paradigm shift has enabled organizations to begin reinventing themselves around the characteristics of the post-industrial firm that features flexible IT as a primary component. They stated that IS compatibility helps break down organizational walls, empowers employees, and makes data, information, and knowledge in the organization readily available. Second, Tapscott and Caston affirmed that IS connectivity enables seamless and transparent organizations, those that are independent of time and space. IS modularity allows the seemingly contradictory achievement of integration yet independence of organizational components, businesses, and modules (Tapscott & Caston). Tapscott and Caston also noted that IS modularity allows the integration of data, text, voice, image, and other types of information into multimedia systems to create user-friendly multimedia systems.

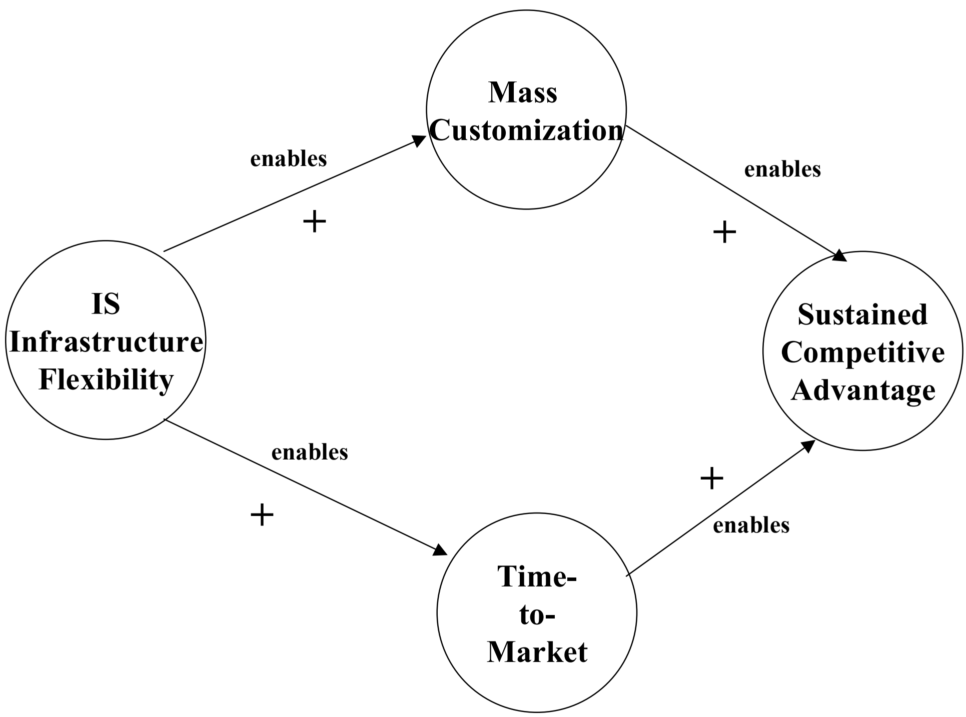
SUSTAINED COMPETITIVE ADVANTAGE

Practitioners of strategic management in organizations are constantly on the lookout for resources that can bring their firms competitive advantage. Porter (1980, 1985) popularized the concept of competitive advantage. Porter said that competitive advantage grows from the value a firm is able to create for its buyers that exceeds the firm's cost of creating the product or service (Porter, 1985). Day and Wensley (1988) emphasized that a complete definition of competitive advantage must describe not only the state of the advantage but also how that advantage was gained.

They wrote that competitive advantage consists of positional and performance superiority (outcomes of competitive advantage) as a result of relative (to the competition) superiority in the skills and resources a business deploys. Positional superiority pertains to how well a company has placed itself in the marketplace so as to have a competitive advantage over others in the industry. Performance superiority refers to the higher returns of a corporation on its assets relative to competitors.

Sustained competitive advantage flows from organizational capabilities and resources that are rare, valuable, non-substitutable, and imperfectly imitable (e.g., Barney, 1986, 1991; Lado & Wilson, 1994). Sustained competitive advantage is obtained by firms implementing strategies that exploit their internal strengths, through responding to environmental opportunities, while neutralizing external threats and avoiding internal weaknesses (Barney, 1991). It is argued below that mass customization and speed-to-market have been shown in the literature to be enablers of sustained competitive advantage. In turn, IS infrastructure flexibility is shown to be related to sustained competitive advantage by acting as an enabler of both mass customization and speed-to-market (see Figure 1).

Figure 1: A model relating information systems infrastructure to sustained competitive advantage through core competencies



MASS CUSTOMIZATION AND COMPETITIVE ADVANTAGE

Customization refers to manufacturing a product or producing a service in response to a particular customer's needs, and mass customization relates to doing it in a cost-effective way. Pine, Peppers, and Rogers (1995) said mass customization "calls for a customer-centered orientation in production and delivery processes requiring the company to collaborate with individual customers to design each one's desired product or service, which is then constructed from a base of pre-engineered modules that can be assembled in a myriad of ways" (p. 105). Mass customization requires a dynamic network of relatively autonomous operating units. The key to the process is that different operating units or modules do not come together in the same sequence every time a product is produced or a service delivered (Pine, Victor, & Boynton, 1993). Each customer's wants and needs dictate the combination of how and when the modules interact to make the desired product or provide the preferred services. Therefore, mass customization allows businesses to offer products and services to a wide variety of customers and meet changing product demands through service or product variety and innovation–all without an increase in costs (Boynton, Victor, & Pine, 1993).

Mass customization has been referred to as "customer of one" marketing (Marion & Kay, 1997), "market of one" (Foley, 1997), "one to one marketing" (Peppers & Rogers, 1998), and "high variety strategy" (Kahn, 1998), among other things. The value of mass customization to organizations has been demonstrated in the literature (Boynton et al., 1993; Gilmore & Pine, 1997; Marion & Kay, 1997; Peppers & Rogers, 1998; Pine, 1993; Pine et al., 1995; Pine et al., 1993). Marion and Kay (1997) discovered, in their examination of companies using mass customization with a build-to-order strategy, that these corporations increased revenues, improved customer service and satisfaction, eased competitive pressures, and made the overall process more efficient. Pine et al. (1995) observed through case studies that the combination of mass customization and elicitation of customer wants and needs led to a learning relationship between company and customer. They reported on a number of examples where customers locked in with companies through the companies' abilities to collect information on these customers' wants and needs and their capability to fulfill these wants and needs very quickly through mass customization. For example, Ross Controls, a 70-year-old manufacturer of pneumatic valves and air controls systems, uses this approach. Through what is called the ROSS/FLEX process, Ross learns about its customers' needs, collaborates with them to come up with design precisely tailored to help them meet those needs, and quickly and efficiently makes the customized products (Pine et al., 1995). The ROSS/FLEX system has boosted revenues by 15% over the past four years. Ross plans through this customized approach to gain customers for life. It seems to be working, as many of its customers refuse to move to any other makers of pneumatic valves. Pine et al. (1995) tell the story of one such customer:

> Knight Industries, a supplier of ergonomic material-handling equipment, gives Ross 100% of its custom business and about 70% of its standard (catalog) business. When a competitor tried to woo Knight way, its president, James Zaguroli, Jr., responded, 'Why would I switch to you? You're already five product generations behind where I am with Ross?' (p. 107)

Ross uses its mass customization capabilities to lock customers in by providing superior service in comparison with its competitors.

Kotha (1995) argued persuasively that for firms competing in rapidly changing environments the ability to maintain a sustainable competitive advantage depended on the firm's capability to create knowledge by interacting both mass customization and mass production approaches. Wind (2001) noted that mass customization offered tremendous opportunities for building companies and gaining strategic opportunities. He also stated that the likelihood of establishing long-term relationships with customers was much greater with mass customization.

Dell Computer Corporation is another example of a company that has used mass customization to gain a sustained competitive edge in its industry (Magretta, 1998). Dell, unlike most of its major competitors, sells directly to customers and builds products to order. Customers can call or go to Dell's Internet site and customize their computers from an array of choices of computer components and software. This direct model gives Dell certain advantages in its industry. The direct model allows Dell to collect a wide variety of information about its customers and, thus, enables Dell to better respond to the needs of its customers. For example, because of the close relationships with its customers, Dell was able to pioneer such service innovations as loading a customer's customized software on its computers during production, placing the customer's asset tags on personal computers as they are being manufactured, and developing easy to open and use computer cases. Dell is also able to keep inventory down very low compared to competitors like Compaq. Dell has an industry low inventory of 8 to 10 days while Compaq and IBM have inventory of at least four weeks or more. This low inventory permits Dell to react very quickly to offer new products and services as they hit the market in the fast-paced computer industry. These and other customization practices have given Dell a competitive advantage that has been difficult for its competitors to overcome.

Companies as diverse as Corning, Westpac, Bally, Citibank's CPG, and Asea Brown Boveri have used mass customization to their advantage. Mass customization allows a customer-centered orientation to production and delivery of services, requiring each corporation to cooperate with individual customers to design each one's specialized product or service, which is then built from a base of pre-engineered modules that can be assembled in almost unlimited ways (Pine et al., 1995).

IS INFRASTRUCTURE FLEXIBILITY AND MASS CUSTOMIZATION

Pine (1996) reported that it takes a highly integrated IS infrastructure to support mass customization. He included among the IS infrastructure design tools, flexible switches and networks, common customer views with image processing and shared databases, computer integrated manufacturing, and work-flow management and coordination software. Such an IS infrastructure automates linkages between processes and relationships between people. For mass customization to succeed in a company, Kahn (1998) claimed that organizations needed more flexible databases, flexible networks, and flexible CAD/CAM systems in their IS infrastructures.

A classic example of how an adaptive IS infrastructure enables and supports mass customization is reported in Boynton et al. (1993). They described how Westpac, a South Pacific financial services conglomerate that had previously dominated banking in its marketplace, moved to more flexible technologies to institute a new strategy of product differentiation. Westpac decided to overhaul its entire IS infrastructure and create a completely new systems development and operational environment. This new environment was called "CS90" (Core System for the 1990s) and was constructed to allow "Westpac to consolidate everything it knows about the processes and expertise required to create new financial products into a set of highly flexible software modules. The result would be a flexible and advanced software engineering that would combine different bits of knowledge quickly and at low cost, in response to changing product and service demands" (Boynton et al., p. 48). The competitive design goals included compatibility to easily mix and match software modules to satisfy customer demands, responsiveness that is the result of highly connected and integrated computer systems, and modularity so that software modules can be reused and recombined across changing products and services. Westpac is now able to fight off niche competitors that might have eroded its market share. With CS90, Westpac can match the cost of niche products while still offering a comprehensive portfolio of financial products and services.

Dell Computer Corporation has used its flexible infrastructure to support its mass customization strategy. The flexible infrastructure at Dell enables coordination across company boundaries to achieve new levels of efficiency and productivity (Magretta, 1998). The flexible infrastructure allows for just-in-time deliveries from a host of suppliers, a highly adaptive manufacturing facility, and the establishment of great relationships with customers. For example, Dell's manufacturing facility makes possible the production of hundreds of different computer combinations to satisfy the customized orders of its customers at costs that are the lowest among its major competitors. Additionally, the infrastructure allows Dell's best customers to access internal support information online in the same way as Dell's own technical-support teams do, saving time and money on both sides. These customers also have access to their own purchasing and technical information about the specific computer configurations they buy from Dell through customized intranet sites that are components in its overall IS infrastructure (Magretta).

Pine et al. (1993) outlined four keys to coordinating process modules for mass customization. These were (1) instantaneous linkages, (2) costless links, (3) seamless links, and (4) frictionless links. For each one of these keys, a flexible IS infrastructure plays a major role in making it possible. For example, these authors noted that mass customizers like Dell Computer, Hewlett-Packard, AT&T, and LSI Logic use special flexible IS infrastructures that are so critical to their "instantaneous" product delivery processes as to be almost impossible without it. "Costless" linkage systems must add as little as possible to the cost beyond the initial investment to create them. USAA uses a company-wide database that allows any employee to access all corporate information about any customer he comes into contact with.

The concept of seamless links is seen with the concept of case managers in organizations like IBM Credit Corporation and USAA (Hammer, 1990). Case managers in each organization use flexible and adaptive IS infrastructures that combine shared databases, integrated computer networks, and expert systems to manage customer sales, concerns, and problems. Once these companies had a specialist in each step in business processes like approving credit to a customer. For example, in the past, a credit application being evaluated in IBM Credit Corporation would have traveled through several departments and involved a relatively large number of people (Hammer). A case manager can now handle all steps in the process because of the powerful and flexible IT at his disposal.

Pine et al. (1993) found the rapid foundation of frictionless teams was an advantage to mass customization. They stated that "the instant teams must be frictionless from the moment of creation, so information and communications technologies are mandatory for achieving this attribute. These technologies are necessary to find the right people, to define and create boundaries for their collective task, and to allow them to work together immediately without the benefit of ever having met" (p. 115). Zipkin (2001) also noted that an important component of a mass customization system is a high-volume, flexible technology-based process that translates information into the physical product.

From the discussion here, it seems like an adaptive, integrated IS infrastructure is omnipresent in organizations where mass customization is prevalent. From these observations, it seems that a flexible IS infrastructure may be a prerequisite for mass customization in corporations.

TIME-TO-MARKET AND COMPETITIVE ADVANTAGE

Time competition can be divided into at least two different categories. One is the so-called "time-to-market" and the other is delivery performance. Time-to-market refers to the elapsed time between product definition and product availability (Vessey, 1991). Delivery performance pertains to the ability to deliver a customized product within a shorter elapsed time than can competitors in the same market and is usually measured in terms of delivery lead time (Handfield, 1993). This type of time competition is related to mass customization because lead time is especially critical in industries with customized products. In fact, a number of firms, including AT&T, General Electric, Hewlett-Packard, Northern Telecom, Toyota, and Seiko, have all taken advantage of shorter delivery times to give themselves a strategic advantage (Bower & Hout, 1988; Dumaine, 1989; Merrills, 1989; Stalk, 1988). Since this type of time competition is related to mass customization, the two are discussed together in this paper. Time-to-market competition is discussed in this section.

George Stalk (1988) was one of the first strategists to propose the idea that time is as much a strategic weapon as money, productivity, quality, and innovation. In his classic article in *Harvard Business Review*, Stalk (1988) presented several examples where Japanese competitors had bested their American counterparts through time-to-market strategies. He noted at the time:

- In projection television, Japanese producers can develop a new television in one-third the time required by U.S. manufacturers.
- In custom plastic injection molds, Japanese companies can develop the molds in one-third the time of U.S. competitors and at one-third the cost.
- In autos, Japanese companies can develop a new product in half the time as the U.S. and German competitors. (p. 49)

In these and many other industries, the Japanese were able to win significant market share due to time-to-market of new products and services.

Vessey (1991, 1992) maintained that time-to-market has become "doubly important" because of the pervasive nature of change. All of this is an attempt to satisfy the seemingly endless appetite for new products in the marketplace. There are new products and services, improved products and services, new and improved products and services, extensions and expansions of products and services, and revisions and enhancements of products and services, all with the intent to keep a steady stream of new products coming to market (Vessey, 1991). Vessey (1992) also cited several examples of corporations benefiting strategically from time-to-market. Ford Motor Company was one such example. Vessey wrote this about Ford:

> Ford Motor Company created "Team Taurus" to develop the Taurus and Sable line of automobiles. Team members included designers, engineers, production specialists, and even customers (who were asked what they wanted in a car). The team addressed profitability and competitiveness in both the design stage and production cycle. In their effort to rationalize the car's mechanical components and the way in which it would be built, they replaced sequential engineering activities with simultaneous input from the diverse group. Before the first clay model was built, they knew how the car would be assembled. Under the previous system, manufacturing managers didn't see the cars to be built until eight or nine months before

production stated. Their success is cited as a significant factor in the renewal of Ford Motor Company. (p. 72)

This example helps to give insight into how new products are being created in modern organizations.

Material Handling Engineering (1992) reported that industry studies by the Boston Consulting Group show that companies that respond twice as fast to customer demands grow at five times the industry average with prices 20% higher. Stalk (1992) stated that as companies focus on time-to-market competition, within about 2 years they are experiencing reductions of wait time of about 60%, inventory reductions of 50% to 60%, and dramatic improvements in quality and labor and asset productivity. Handfield (1993), in gathering data from 35 managers in large global organizations, asserted that time has been recognized as a critical element of global competitiveness. He stated that companies like AT&T, General Electric, Hewlett-Packard, Northern Telecom, Toyota, and Seiko have all recognized the importance of shorter product development and delivery in providing a strategic advantage. In consumer goods, an empirical study showed that the second firm to enter a market did only 71% as well as the innovator, and the third firm did only 58% as well (Urban, Carter, Gaskin, & Zofia, 1986). Robertson (1988), in a study of pioneer advantages in industrial markets, found that market pioneers tend to achieve substantially higher market shares, the early follower can expect to do only 76% as well as the market pioneer, and the late entrant only 51% as well as the pioneer. Although disadvantages for companies that are first to market have been cited, it is generally accepted that innovators gain strategic advantage from being first (Robertson, 1993; Vessey, 1991).

IS INFRASTRUCTURE FLEXIBILITY AND TIME-TO-MARKET

The revolutionary rise in the capability and flexibility of IT has fundamentally altered the product and service design process, lessening inefficiencies and enabling new levels of performance (Hull et al., 1996). Flexible IT, such as computer-aided design and computer-aided manufacturing, has allowed better links between design and manufacturing and brought about more manufacturing-friendly product designs. Flexible IT has also enhanced the capability of organizations to more rapidly respond to the changes in product design resulting in faster product development and reduced costs (Hull et al., 1996; Vessey, 1992).

Hull, Collins, and Liker (1996) explored the effects of flexible IS infrastructure on two concurrent engineering practices. Concurrent engineering is important to time-to-market because it bring together multiple functions in decision making on product design so that downstream issues such as manufacturability, marketability, serviceability, and total life cycle problems are anticipated at early steps (Clark, Chew, & Fujimoto, 1992; Hartley, 1992; Susman & Dean, 1992). Anything to facilitate concurrent engineering should also promote time-to-market. Two core concurrent engineering practices are early simultaneous influence (ESI) and in-process design controls (IDC). ESI refers to the participation of multiple upstream, and downstream functions in initial stages of the product design process. Hull et al. noted: “high levels of early involvement increase opportunities for evaluating varied design alternatives and selecting ones which may reduce the risks of costly, late stage problems” (p. 134). IDC refers to common design methodologies and protocols employed by the participants (Hull et al., 1996). IDC emphasizes in-process inspection instead of relying on final inspections, much like in process quality control.

Hull et al. (1996) surveyed manufacturing engineering from 74 Fortune 500 companies to try to determine if the combination of flexible IT, ESI, and IDC would lead to improvement in product development performance. Using statistical tests on the data from these companies, they found that flexible IT has a significant effect on both ESI and IDC. They found that the greater the use of flexible IT, the greater the positive effects of ESI on product development performance. In addition, they found, in the same way, that the greater the use of flexible IT, the greater the positive effects of IDC on product development performance. In both cases, flexible IT played a vital role in helping cross-functional teams of engineers achieve higher levels of performance.

The above study gives evidence that a flexible IS infrastructure is critical to the success of time-to-market initiatives. There is also other evidence that flexible IT enables a time-to-market competency. Vessey (1992) noted that “time to market, with its inherent product and process design, is a function of speed of information which must be shared by engineering and manufacturing” (p. 72). Because of this requirement, he declared that integrating enterprise-wide IT was a necessity in the ability for all team members to know what was occurring throughout the design process. He surmised that ancillary and immediate benefits could accrue from the elimination of redundant information and an integration of disparate data sources. Flexible IT, Vessey concluded, was important in establishing a seamless flow of information to all team members.

A case featuring Nissan also shows the importance of a flexible IS infrastructure for time-to-market. Nissan has built an intelligent system, known as Intelligent Body Assembly System (IBAS), to link production facilities around the world, making it a highly proactive assembly system (Material Handling Engineering, 1992). A key component of this system is a worldwide network based on production process data from each department within system. The system supports concurrent engineering, which is the central component of the Nissan production. The system makes it possible for Nissan to begin production preparations of new types of vehicles immediately at their manufacturing plants in any country and gives Nissan a competitive advantage. Again, as with the core competency of mass customization, a flexible IS infrastructure seems to enhance the core competency of speed-to-market in organizations.

IS INFRASTRUCTURE FLEXIBILITY AND SUSTAINED COMPETITIVE ADVANTAGE

The link between IS infrastructure and a sustained competitive advantage has been hypothesized through the discussions in this paper. IS infrastructure is firmly established as an enabler of two competencies that are shown to be closely related to sustained competitive advantage in organizations. Strong links between IS infrastructure flexibility and sustained competitive advantage have not been firmly established in the research literature. This paper has been a start in the quest to better understand how a flexible IS infrastructure might be a causal agent for sustained competitive advantage. The evidence presented in this paper suggests that a flexible IS infrastructure enables certain core competencies that, in turn, are closely aligned with sustained competitive advantage in organizations.

The two core competencies presented in this paper are not meant to be comprehensive. They are held up as examples of how a flexible IS infrastructure enables core competencies in an organization to give sustained competitive advantage. Other core competencies that could have been examined include organizational learning and knowledge management. These and others are left for other research studies. However, the value of a flexible IS infrastructure has been clearly indicated. Further research on the relationships between IS infrastructure, core competencies, and sustained competitive advantage is definitely needed.

CONCLUSION

The investment in IT by modern organizations continues to skyrocket (BusinessWeek, 1993, 1997). The expenditures on IT in many organizations exceed the spending on all other capital stock (BusinessWeek, 1997). With investments of this magnitude, it becomes absolutely necessary to wring as much value from IT as possible. Researchers and practitioners had once focused on the value of so-called "strategic information systems" as the "Holy Grail" of IT. These systems were seen as valuable in bringing competitive advantage to the companies that adopted them. However, later evidence cast doubt that these SISs alone would yield sustained competitive advantage.

More recently, researchers and practitioners have started to turn to IS infrastructure as a possible source of sustained competitive advantage. This paper has provided evidence of the value of the primary characteristic of an IS infrastructure, its flexibility. This paper has linked the concept of IS infrastructure flexibility as being an enabler with certain core competencies that have been empirically related to sustained competitive advantage in the research literature and in practice. By enabling these competencies, the value of IT, specifically the IS infrastructure, should be recognized.

The stakes are high when investing in IT; therefore, the returns must be high. The challenge presented by this paper linking IS infrastructure flexibility to sustained competitive advantage through competencies like mass customization and time-to-market is to move forward to empirically examining these assertions. If the model hypothesized here can be firmly established, researchers must then turn their attention to discovering the strategies that best accommodate using an adaptive IS infrastructure as an enabler of core competencies.

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Chapter V

Theoretical Justification For IT Infrastructure Investments

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The strategic importance of building highly capable information technology (IT) infrastructure has become a crucial management issue of the 1990s and beyond. However, in spite of the numerous benefits attributed to IT infrastructure, these claims remain unsubstantiated. This problem is due, in part, to inadequate conceptualizations of IT infrastructure and its measurement as well as a lack of theoretical frameworks for explaining its impacts. To address these problems, this paper proposes a theoretical framework to justify the value-creating potential of IT infrastructure investments. First, we provide a conceptual framework that describes the nature of IT infrastructure and its related components. Next, we discuss the role of IT infrastructure as a competitive weapon and identify three areas where it may create strategic value for the firm: responsiveness, innovativeness, and economies of scope. For each area, specific theories are used and research propositions are developed to guide future infrastructure research.

The need for building a responsive information technology (IT) infrastructure has emerged as a critical IT management issue of the 1990s and beyond (Broadbent & Weill, 1997; Broadbent, Weill, O'Brian; Neo, 1996; Keen, 1991; Koch, 1997;

Niederman, Brancheau, & Wetherbe, 1991; Sambamurthy & Zmud, 1992; Venkatraman, 1991; Weill & Broadbent, 1998).

> An information technology infrastructure is vitally important to companies, particularly those in industries going through dynamic change, those re-engineering their business processes, and those with widely dispersed operations (Broadbent & Weill, 1997, p 77).

For many companies, IT infrastructure investments are long-term commitments that account for more than 50% of the IT budget and about 4% of revenues (Broadbent & Weill, 1997). Consequently, many argue that major infrastructure decisions warrant the attention of senior management (Broadbent & Weill; Davenport & Linder, 1994; Duncan, 1995; Koch, 1997; Koeller, 1994; Sambamurthy & Zmud, 1992).

> Infrastructure is becoming too important to the company's survival to leave the decisions up to the IS department alone. CIOs can no longer afford to say, "Trust me, I'm managing the infrastructure." The numbers have simply gotten too big. (Koch, 1997, p. 6)

IT infrastructure has become vitally important as managers seek to insure standardization, compatibility, and interoperability among potentially diverse organizational information systems. Furthermore, the seemingly endless variety of hardware, operating systems, and application development tools have placed an added burden on IS managers to maintain a consistent IT architecture to avoid fragmented systems, lack of integration, or, as Lindquist (1992) refers to, "islands of automation." Consequently, the development of corporate IT infrastructure has become an urgent activity for many organizations to insure some degree of cohesiveness among the firm's diverse computers, operating systems, networks, core databases, and mission-critical applications (Niederman et al., 1991). Notwithstanding this, a heightened awareness by senior management of the competitive potential of IT infrastructure has contributed to its importance as a critical IT issue (Barney, 1986; Keen, 1991; Niederman et al.).

While numerous articles cite the value-creating potential of IT infrastructure (Campanelli, 1993; Cox, 1993; Rockart, 1988; Vincent, 1993), much of the evidence for infrastructure benefit lies in the realm of conjecture and anecdote (Duncan, 1995). Consequently, a clear theoretical framework for assessing the value-creating capabilities of IT infrastructure is lacking. To address this issue, we have undertaken to articulate how IT infrastructure creates value and then to provide theoretical arguments for substantiating these claims. Answers to such issues are critical to senior managers who face the daunting task of justifying infrastructure expenditures (CSC Index, 1993; Duncan; Markus & Soh, 1993; Parker & Benson, 1988). First, we provide a conceptual framework that describes the nature of IT infrastructure as a shared corporate resource composed of physical assets, intellectual assets, and IT standards. Next, we discuss the role of IT infrastructure as a competitive weapon and identify three areas where it may create strategic value for the firm. For each area, specific theories are elucidated to provide a theoretical basis for substantiating each of these IT infrastructure capabilities. Subsequent research propositions are offered to guide future infrastructure research. The paper concludes with a discussion of limitations, research challenges and potential strategies to overcome them.

CONCEPTUAL FRAMEWORK OF IT INFRASTRUCTURE

The common theme that emerges from the evolving conceptualization of IT infrastructure is that it is an organizational resource typically coordinated by some form of central IS organization and shared across organizational units (Davenport & Linder, 1994; Duncan, 1995; Earl, 1989; Henderson, 1990; McKay & Brockway, 1989; Niederman et al., 1991; Rockart, 1988; Weill, 1993). For example, a telecommunications network coordinated by the corporate IS department and shared by multiple business units would constitute a shared organizational IT capability.

From this perspective, IT infrastructure can be viewed as a shared resource that consists of both physical and intellectual IT assets (Broadbent et al., 1996; McKay & Brockway, 1989; Sambamurthy & Zmud, 1992; Venkatraman, 1991; Weill, 1993). Whereas the physical component of infrastructure refers to actual IT artifacts (e.g., client-server networks, data, e-mail), the intellectual component includes the specific body of IT-related knowledge, skill sets, and experience. These intellectual assets act as the "mortar" that binds the physical IT components into robust and functional IT services (McKay & Brockway). Like the physical view, the intellectual view by itself forms an incomplete picture of infrastructure. A firm may have the necessary knowledge, skill sets, and experience with IT; however, the IT infrastructure is incomplete in the absence of the physical IT assets to which this expertise can be applied. Weill (1993) provides a clear definition that conceptualizes IT infrastructure both in terms of intellectual skill sets as well as specific physical IT resources. He defines IT infrastructure as:

> The base foundation of IT capability budgeted for and provided by the information systems function and shared across multiple business units or functional areas. The IT capability includes both the technical and managerial expertise required to provide reliable services. (p. 553).

While firms may possess the requisite IT assets (physical and intellectual) for a reliable infrastructure, corporate IT standards and policies governing the use of these assets may enhance the firm's ability to capitalize on these assets' deployment. A standard can be defined as a definitive rule, principle, or guideline established for the purpose of instituting uniformity in organizational behaviors and practices. Related to the IT context, infrastructure standards are defined as guidelines that dictate how IT assets are to be acquired, managed, and utilized within the organization. Thus, it is conceivable that a given firm may have a well-developed IT asset base (in terms of physical and intellectual IT assets); however, a lack of standards on how to utilize these assets may result in an inability to integrate the systems across the organization. Consequently, organizational routines or standards may need to be established to insure that human expertise is applied to IT assets in meaningful ways (Darnton & Giacoletto, 1992; Turnbull, 1991). Weill (1993) highlights the importance of IT standards:

> The provision of a reliable IT infrastructure implies an architectural responsibility. Sufficient standardization of computing is required to ensure that business units and functional areas can take advantage of the infrastructure. Therefore, a firm-wide architecture [set of standards] is an integral part of providing an IT infrastructure. (p. 555)

The use of data definition standards provides a useful illustration of these concepts. A firm may have the physical assets (the database) as well as the human expertise required to use these assets; however, standards provide the mechanisms that guide how these two assets interact. Data definition standards dictate a set of uniform rules so that the overall organization can benefit from a consistent set of meanings and names for the commonly used data. Failure to provide these standards may result in data redundancy, confusion over data names, and an inability to integrate the common data definitions across the whole organization.

Thus, while prior conceptualizations have primarily defined IT infrastructure in terms of physical and intellectual assets, we argue that technology standards form a critical third component of IT infrastructure. We distinguish standards from intellectual assets from the standpoint that standards normally become routinized as part of the organizational memory (Huber, 1991; Walsh & Ungson, 1991) whereas intellectual assets may be more transient and less routinized. As Table 1 illustrates, IT infrastructure can be conceptualized as a shared corporate resource that consists of physical and intellectual components "held together" by organizational standards regarding their use.

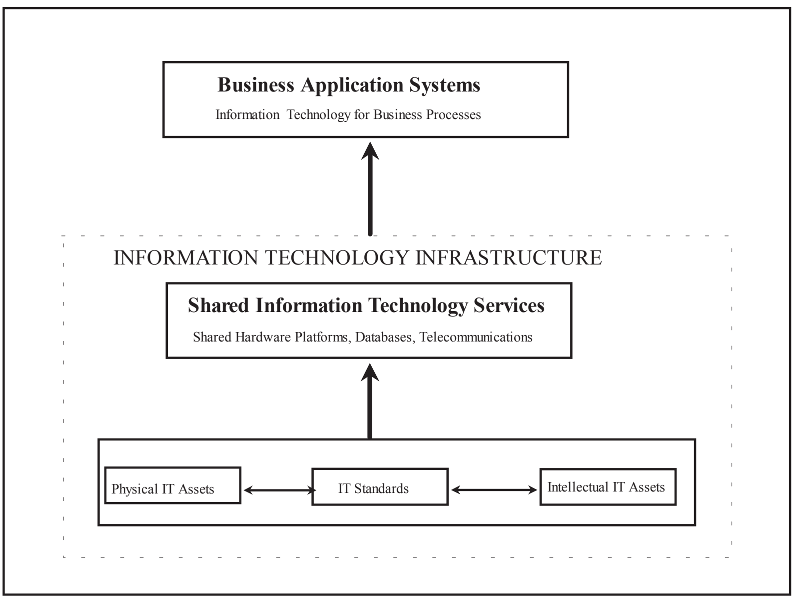
Figure 1 presents a framework that builds upon the notion of IT infrastructure that extends beyond the concept of a purely physical infrastructure to one that contains physical assets, intellectual assets, and IT standards. Shared IT services are the realization of the infrastructure and their delivery into business applications. Shared services are a result of the blending of physical and intellectual assets according to the rules and guidelines prescribed by standards. A shared IT service represents any IT capability available to the whole enterprise and not just to a single functional area or business unit. Some examples of shared IT services are distributed databases, telecommunication networks, electronic data interchange, e-mail, and videoconferencing (Scott Morton, 1991). They provide the springboard or platform that enables organizational subunits to be able to develop specific business applications. In contrast, the purpose of business application systems is to provide business functionality (Weill, 1993). Although business applications may be functionally specific, they use the underlying shared IT services that have been provided by the central IS department.

This conceptual framework provides a "layered" perspective of enterprise-wide information systems where the IT infrastructure forms the bedrock of an organization's information systems capability. It is upon this core infrastructure that value-creating business application systems are developed.

Table 1: Dimensions of IT infrastructure

Dimension of IT Infrastructure	Description	References
Shared Resource	Infrastructure is a shared resource managed by corporate IS and made available across organizational units.	Davenport & Linder, 1994; Earl, 1989; Henderson, 1990; McKay & Brockway, 1989; Niederman, Brancheau, & Wetherbe, 1991; Rockart, 1988; Weill, 1993
Physical Assets	Physical IT artifacts that include such components as: operating systems, hardware platforms (e.g., client/server), networks, email capabilities, applications development tools, data, and videoconferencing capabilities	Burger, 1994; Earl, 1989; Gunton, 1989; Markus & Soh, 1993; McKay & Brockway, 1989
Intellectual Assets	Core IT skill sets and knowledge in such areas as: software development skills (e.g., Visual Basic), database administration, systems analysis, project management, network management, IT human resource management	Duncan, 1995; Broadbent & Weill, 1997; Davenport & Linder; 1994; Weiss & Bimbaum, 1989
Standards	IT standards act as a glue that links the use of physical and intellectual IT assets.	Darnton & Giacolette, 1992; Turnbull, 1991; Weill, 1993

Figure 1: Conceptual framework of IT infrastructure



VALUE-CREATION POTENTIAL OF IT INFRASTRUCTURE

The essence of a business strategy is to denote the set of choices the firm intends to make so it can either perform different activities or perform activities differently as compared to rivals. The combination of activities to be completed as demanded by its selected strategy should allow the firm to deliver greater value to customers or to create comparable value at a lower cost, or both (Porter, 1996). Thus, at its core, business strategy is a reflection of how the firm intends to create value (Campbell & Alexander, 1997).

A fundamental assumption of this paper is that the development of IT infrastructure represents a core business strategy that allows firms to create value relative to its competition. By nature, IT infrastructure may be difficult to replicate(Venkatraman, 1991). Consequently, firms may be able to leverage this critical resource to create value on a sustained basis, particularly if the infrastructure is inimitable or not easily duplicated by others. The following paragraphs build upon these arguments to provide an underlying theoretical case for viewing IT infrastructure as a potential source of competitive advantage. Following this, we identify three crucial areas whereby IT infrastructure may create value for the firm. For each of these areas, underlying theoretical perspectives are developed to provide a basis for justification for IT infrastructure investments. Where applicable, research propositions are offered as a guide for future examination of the value-creating potential of IT infrastructure. The resource-based view of organizations can be used as a theoretical perspective to explain how IT infrastructure may be viewed as a source of competitive advantage. According to this theory, the internal resources of any firm can be one source of sustained competitive advantage. If one firm has a particular resource not easily created, bought, substituted, or imitated by its competitors, then this resource confers some degree of sustained competitive advantage on the firm who possesses it. Miller and Shamsie (1996) quote Barney (1991) to provide a clear articulation of this perspective:

> Resources are said to confer enduring competitive advantage to firms to the extent that they are rare or hard to imitate, have no direct substitutes, and enable companies to pursue opportunities or avoid threats. (p. 520)

If one views infrastructure solely as a set of artifacts (i.e., hardware, software, telecommunications capabilities) or technical expertise to be acquired (i.e., programming skills), there is no compelling argument for competitive advantage since these components of infrastructure are readily available to most firms. However, the management expertise needed to successfully build infrastructure is one component not easily imitated (Mata, Fuerst, & Barney, 1995). The primary reason for this is that managerial expertise is often developed over time and is based on tacit knowledge and socially complex processes. As Miller & Shamsie (1996) point out, management expertise is a knowledge-based resource that is often very subtle and extremely difficult for other firms to understand and imitate.

The resource-based view would suggest that senior management skill at (1) understanding business needs, (2) working with functional business unit managers, (3) coordinating IT activities, and (4) anticipating future IT needs represents a knowledge-based resource critical to the development of IT infrastructure–one not easily replicated by other firms (Mata et al., 1995). Consequently, barriers to imitation of IT infrastructure may be a function of the level of senior management skill at developing IT infrastructure as well as specialized IT knowledge and experience. To the extent that senior management skill is a heterogeneous resource and inimitable, then the firm(s) possessing these key knowledge resources may have a source of sustained competitive advantage.

Based on our review of the IS literature, we have identified three crucial areas of value creation for firms who are able to successfully develop and implement high capability IT infrastructures. The following pages describe each area of value creation and provide relevant theoretical perspectives to substantiate these claims.

For the purposes of this paper and subsequent research propositions, we will use the Broadbent et al. (1996) measure of infrastructure capability to conceptualize the degree or level of comprehensiveness of a given firm's IT infrastructure. Using their definition, infrastructure capability is defined as a multidimensional construct that includes the level of shared infrastructure services combined with the reach and range of the infrastructure. Reach determines the extent of locations that infrastructure can link to, while range determines the extent to which information generated by the various systems can be shared across organizational units (Keen, 1991).

Responsiveness

One aspect of organizational survival in the 1990s and beyond lies in the ability of firms to quickly adapt products and services in response to changing business conditions. While a number of factors may influence a firm's responsiveness, many argue that the firm's IT infrastructure capability is vitally important to insure firm success in recognizing new business opportunities and responding in a timely and effective manner to changing competitive conditions (Caron, Jarvenpaa, & Stoddard, 1994; Duncan, 1995; Earl & Kuan, 1994; Furey & Diorio, 1994; Grover, Teng, & Fiedler, 1993; Gunton, 1989; Keen, 1991; McKay & Brockway, 1989; Mead & Linder, 1987; Niederman et al., 1991; Railing & Housel, 1990; Ramcharamdas, 1994; Venkatraman, 1991; Wastell, White, & Kawalek, 1994; Weill, 1993). Venkatraman states:

> If we are not able to attain this goal [building IT infrastructure], the inflexibility and slow adaptability of the information systems structure itself may act as an inhibitor to the rate of change necessary to survive in the highly volatile environment of the 1990s (p. 43).

Others suggest that IT infrastructure allows firms to recognize fleeting business opportunities, to seize them ahead of their rivals, and to disrupt the existing basis of competition (Bourgeois & Eisenhardt, 1988; D'Aveni, 1994; Smith, Grimm, & Gannon, 1992). Thus, depending on its level of capability, a firm's IT infrastructure may be viewed as either an inhibitor or as an enabler of firm-wide responsiveness.

Responsive capability suggests that firms have two distinct yet related competencies. First, organizations must be able to recognize threats and opportunities in the business environment. Second, firms must be able to respond to these threats and opportunities through some form of coordinated action.

Firms recognize threats and opportunities through monitoring (e.g., scanning) their respective environment and attaching meaning to (e.g., interpreting) these environmental cues. Based on these interpretations, firms will act in some coordinated fashion to either counter threats or take advantage of strategic opportunities. Thus, the ability of firms to make sense of their respective environments and to act upon these "interpretations" in a meaningful way will determine their level of responsiveness to the business environment. Organizational learning theory is one useful perspective that effectively captures the notion of organizations as interpretive systems that continually gather data, attach meaning to it, and take action based on these interpretations. This theory posits that organizations must be able to learn continually in order to survive and to remain responsive to changing business conditions as a matter of competitive survival (Daft & Weick, 1984; Huber, 1991; Morgan, 1986; Senge, 1990; Walsh & Ungson, 1991). Greater learning capabilities will enhance the firm's abilities to recognize strategic threats and opportunities and will increase the likelihood of survivability over the long run (Barr, Stewart, & Huff, 1992). This theory also implies that firms may vary in their ability to learn depending upon the types of structures, policies, and processes embedded with the firm. Some of these organizational features may facilitate learning and adaptation while others may hinder the process. Consequently, firms must strive to "embed" those structures, processes, and policies that will facilitate their ability to recognize or make sense of their respective business environments.

IT infrastructure represents one such structure that may enhance the firm's learning capabilities. According to Huber (1991), effective learning systems must be designed to efficiently acquire, interpret, and disseminate knowledge and information among the firm's stakeholders. Thus, as firms are able to effectively scan the environment for information (acquisition), attribute meaning to this information (interpretation), and share these meanings among stakeholders (dissemination), this should have a significant impact on their responsive capabilities. We argue that high capability infrastructure will provide highly sophisticated mechanisms that facilitate acquisition, interpretation and dissemination of information and knowledge among the organization's key stakeholders. High levels of reach will provide greater capability to gather information from a wide variety of internal as well as external sources while increased range will enable the organization to rapidly disseminate this intelligence seamlessly through the organizational network. A wide variety of shared communication services (e.g., e-mail, videoconferencing, collaborative tools) provided by the infrastructure will facilitate the sharing of individual interpretations and mental models. These arguments suggest that high capability infrastructures will facilitate higher levels of learning and subsequent capabilities to recognize and respond to strategic threats and opportunities.

Once a firm has recognized a strategic threat or opportunity, some form of coordinated action becomes necessary. However, given the complex nature of today's organizations, the ability to take action may be extremely difficult and require high levels of integration of tasks and processes across a potentially wide range of organizational stakeholders. In the absence of high levels of integration, the organization's ability to coordinate complex tasks may be lowered, thereby hinder-ing firm-wide responsiveness. These arguments are supported by coordination theory (Malone, 1987). This theory proposes that organizational success is dependent on the ability of the firm to coordinate complex tasks among multiple stakeholders. This is accomplished through coordination mechanisms that facilitate task management throughout the firm. These mechanisms may consist of organizational structures, processes, or routines all designed to facilitate task coordination.

IT infrastructure may be conceptualized as a type of organizational structure that will facilitate high levels of task and process integration, thereby enabling greater firm responsiveness. High levels of reach and range associated with high capability infrastructure will enable the firm to share data seamlessly across a wide variety of IT platforms (range) and to connect electronically to a potentially much wider audience of internal as well as external stakeholders (reach). Through these capabilities, higher levels of data sharing will be achieved which will facilitate task and process coordination across multiple business units. Using coordination theory as an underlying paradigm, IT infrastructure can be conceptualized as a type of organizational structure that facilitates complex task coordination through providing seamless sharing of data across a wide range of organizational stakeholders.

These arguments suggest that high capability infrastructures may increase the firm's learning capability through providing seamless connected networks that enhance the ability to make sense of the environment (e.g., scanning and interpretation) and to disseminate this information through all layers of the organization. Furthermore, through providing high levels of reach and range, high capability infrastructure may also facilitate the ability to take action through leveraging the firm's ability to coordinate complex tasks across a wide range of organizational stakeholders. From these arguments, the following research proposition is offered:

Proposition 1: Companies with higher levels of IT infrastructure capability will be more responsive at adapting their information systems to accommodate changing business conditions than will companies with less capable infrastructures.

Innovativeness

An innovation is an "idea, practice, or object that is perceived as new by an individual or other unit of adoption" (Rogers, 1983, p. 11). According to this definition, an innovation may consist of a specific technology (e.g., a distributed database) or as a practice or policy (e.g., corporate IT standards). "Regardless of the type of innovation, its purpose is to reduce the uncertainty in the cause-effect relationships involved in achieving a desired outcome" (Rogers, p. 12). For example, data warehousing could be viewed as an IT innovation that reduces uncertainty in managing and interpreting corporate data. Given the potential for uncertainty reduction in the business environment, the ability of the firm to successfully innovate with information technology is an essential organizational activity. Consequently, it is extremely important for firms to identify and create those underlying conditions that will foster higher levels of corporate IT innovation.

One precondition for innovation noted by Rogers (1983) is that decision makers need to be aware of the innovation, how it functions, and how it might be applied to the corporate setting. As expected, firms with higher embedded capacities to recognize potential IT innovations may be much more likely to engage in higher levels of innovative activity. Absorptive capacity is one theoretical perspective that can be used to support this argument. Absorptive capacity is "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends" (Cohen & Levinthal, 1990, p. 128). This ability is a function of organizational members' individual absorptive capacities that are determined by members' prior knowledge, expertise, and communication with each other and with external entities. An underlying assumption of this theory is that knowledgeable individuals act rationally to evaluate options and make decisions about technology innovation. Furthermore, the extent to which decision makers already possess knowledge, skills, experience, and familiarity with a technology affects their ability to assess issues that arise in planning for the technology (Sambamurthy, Venkatraman, & Desanctis, 1991). Thus, it can be argued that firms with greater levels of absorptive capacity will have greater capabilities to evaluate opportunities, to establish well-defined decision-making guidelines (Byrd, Sambamurthy, & Zmud, 1995), and to effectively use resources (Cash, McFarlan, McKenney, & Applegate, 1992).

Following this line of reasoning, it can be argued that the presence of high capability infrastructure will, by nature, assume high levels of IT expertise and knowledge as well as tacit managerial knowledge in funding and building the infrastructure. Consequently, firms with higher capability infrastructure will very likely have higher levels of absorptive capacity, which, in turn, will lead to higher levels of innovation with information technology.

High capability infrastructure may also foster innovative activity through providing a range of business options that may be exercised in the future (Kanbil, Henderson, & Mohsenzadeh, 1992). Keen (1991) uses the term "business degrees of freedom" to argue the same point; that highly effective (e.g., high capability) infrastructures provide a "springboard" from which future, yet still undetermined, IT initiatives may take place. Thus, today's investment in Internet infrastructure may spawn future IT initiatives that management has yet to conceptualize. In the absence of such an infrastructure, these types of innovations might not occur.

High capability infrastructure may also spawn further IT innovation through facilitating experimentation with new technology (McKay & Brockway, 1989). Using the example above, the existence of high capability Internet infrastructure may facilitate the firm's ability to experiment with new innovative Web-based technologies such as e-commerce development tools, Web-based collaboration tools (e.g., Lotus Notes), as well as supply chain management tools. These arguments are summarized by Proposition 2:

Proposition 2: Organizations with highly capable infrastructure will have a greater tendency to innovate with information technology than will companies with less capable infrastructures.

Economies of Scope

There is considerable support for the notion that high capability infrastructures may reduce the cost and time for completion of strategic business application systems (Duncan, 1995; Fayad & Schmidt, 1997; Grossman & Packer, 1989; Keen, 1991; Niederman et al., 1991; Sambamurthy & Zmud, 1992; Schmidt & Fayad, 1997; Venkatraman, 1991; Weill, 1993). The rationale for this claim is that infrastructure provides shared organizational resources that lower marginal costs as usage is spread over a wide range of organizational stakeholders. For example, assume that a given organization provides a shared telecommunications network that is available to be used by all business units. If units A and B each need to develop their own distributed customer service network, the cost and time of accomplishing this should be lower if A and B use the shared resources that currently exist as opposed to independently developing their own telecommunications infrastructure and standards.

Teece (1980) uses the concept of economies of scope to describe how organizations may achieve higher levels of organizational efficiency through the common and recurrent use of specialized and indivisible physical assets. Applied to the IT context, this paradigm suggests that firms may reduce IT costs through the recurrent use of common or shared IT assets across products, markets, and business units. These assets may be either intellectual or physical in nature. To the extent that these assets can be shared among multiple business units in a recurring fashion, economies of scope will exist and the marginal cost of "production" will be lower than if all business units had to produce the given output independently.

Therefore, in environments characterized by high capability infrastructures, business units may draw from a wide array of shared IT products and services (e.g., networks, distributed databases, maintenance, e-mail, videoconferencing, applications development tools, methodologies, specialized expertise) in efforts to develop strategic business applications. To the extent that business units can utilize these shared assets in a recurring fashion to develop business applications, then they are able to achieve economies of scope through lowering the marginal costs of applications development. This suggests the following research proposition:

Proposition 3: The development cost and time of business application systems should generally be lower for firms with more capable IT infrastructures than for companies with less capable infrastructures.

These three propositions suggest that high capability infrastructure may help firms to create value through (1) providing greater responsive capabilities to business needs, (2) facilitating greater levels of IT innovation, and (3) reducing the time and cost to develop strategic business applications. Taken together, we argue that these three areas of benefit may enhance a firm's competitive position with respect to rival organizations. Table 2 summarizes these arguments.

RESEARCH IMPLICATIONS

To effectively address the propositions outlined above, researchers face a number of challenging issues. One of the most critical issues involves the measurement of IT infrastructure. While concepts related to infrastructure capability, reach and range are intuitively appealing, continued research efforts must focus on refining the concept of infrastructure capability as well as pursuing alternative measures of IT infrastructure.

One alternative measure, conceptualized by Duncan (1995), centers on the concept of infrastructure flexibility, which refers to the degree to which IT resources are shareable and reusable. Under this perspective, infrastructure flexibility determines a firm's ability to engage in rapid innovation and continuous improvement of IT systems. Thus, it could be expected that a firm with high infrastructure flexibility could make rapid changes to information systems in support of changing business needs while firms with low flexibility infrastructures will be unable to imitate the IT innovations of its competitors. The presence of high infrastructure flexibility also implies a high degree of reusability and interchangeability among its components (Cusumano, 1991; Ross, Beath, & Goodhue, 1996). While the concept of infrastructure flexibility has intuitive appeal, the question of how to operationalize this construct remains unanswered.

We argue that researchers must first contend with these measurement issues before attempting to measure the effects of infrastructure. Another difficulty in measuring infrastructure lies in determining how to segregate it from non-infrastructure-related investments. In today's interconnected Internet environment, some might even argue that all IT assets represent a component of infrastructure. One possible approach to measuring this construct would be to conduct a field study involving IT managers and senior executives to identify the core dimensions of IT infrastructure. Once completed, this study could yield a set of intellectual and physical assets as well as standards that industry executives associate with highly effective IT infrastructures.

A second challenge of studying IT infrastructure is that it may be extremely difficult to link infrastructure investments with specific benefits (e.g., innovation). One major reason for this is that firms often view infrastructure as a long-term investment with some expectation of future benefits. Since there may be considerable time lags between actual infrastructure investments and the realized benefits of these investments, researchers may find it difficult to effectively link benefit to specific infrastructure investments. In addition to time delays, the complex nature of organizations may make it extremely difficult for researchers to effectively isolate the impacts of infrastructure. Consequently, some believe the benefits of IT

Table 2: Value-creation potential of high capability infrastructures

Value-Creating Potential of IT Infrastructure	**Description**	**Theoretical Perspective**
Responsiveness	High capability infrastructure will enhance the firm's ability to learn (e.g. sense the environment) and to take coordination action thereby resulting in higher levels of firm-wide responsiveness	*Organizational Learning Theory*-responsive organizations are able to effectively recognize problems and opportunities through knowledge acquisition, interpretation and dissemination. High capability IT infrastructures are one type of structure that helps organizations to interpret their respective environments.
Innovativeness	High capability infrastructure (1) provides a basis for future, yet still undetermined IT innovations and (2) fosters higher levels of experimentation with innovative information technologies.	*Coordination Theory*-highly responsive firms are able to coordinate complex tasks across a wide range of stakeholders. High capability IT infrastructures will facilitate task coordination through providing high levels of data sharing (range) and seamless interconnection to a wide range of hardware platforms (reach).
Economies of Scope	High capability infrastructure provides shared resources that facilitate reduction inIT-related costs.	*Absorptive Capacity*-firms with high capability infrastructures will have higher levels of management and IT expertise and knowledge; thereby leading to an increased capability to recognize and envision ways to use innovative information technologies. *Economies of Scope*-firms may reduce IT costs through the recurrent use of common or shared IT assets across products, markets, and business units.

infrastructure may be difficult, if not impossible, to quantify (CSC Index, 1993; Duncan, 1995; Markus & Soh, 1993; Parker & Benson, 1988).

To counter some of these effects, one possible solution would be to conduct an event-based study that focuses on a specific industry over time and attempts to relate specific IT infrastructure investments (e.g., Internet-based capabilities) to those outcomes outlined in this paper. By focusing on a specific industry, certain confounding effects attributable to different organizational contexts might be minimized. In addition, by concentrating on specific (discrete) IT infrastructure investments, the problem of distinguishing infrastructure from non-infrastructure-related investments might also be mitigated.

Another area that offers rich potential for infrastructure research is to examine the role of senior management in building infrastructure capability. The resource-based view of the firm suggests that senior management expertise and knowledge represents one type of "asset" not easily imitated by other firms (Mata et al., 1995). Consequently, a study of this nature might focus on the nature of senior management roles, relationships, and characteristics to discover what factors potentially offer the greatest contribution to building infrastructure capability.

LIMITATIONS AND CONCLUSIONS

This paper has provided a set of theoretical perspectives to provide support for and to explain the purported benefits (e.g., value-creating capabilities) of IT infrastructure. However, we acknowledge the potential for a wide range of other theoretical perspectives to be used to explain the same phenomena discussed herein. In addition, one cannot assume that these benefits are independent of one another. Although care was taken to identify distinct areas of value creation, it can be argued that there is some degree of overlap among the three areas of responsiveness, innovation, and economies of scope. Finally, this paper has deliberately chosen to limit its focus by concentrating on three specific areas of value creation with the realization that IT infrastructure may have other significant organizational impacts not addressed in this work.

A great deal has been said about the necessity of building infrastructure capability; however, little has been done to test the validity of these claims. This paper has addressed these shortcomings through first providing a clear conceptualization of IT infrastructure and then by offering theoretically grounded research propositions to test specific claims made regarding how IT infrastructure might create business value in three specific areas: responsiveness, innovativeness, and economies of scope. These research propositions suggest that high capability IT infrastructure may be viewed as a competitive weapon to the extent that it is not easily duplicated or imitated by others. Continued research in this area is important given the long-term, high-cost nature of IT investments and the difficulty faced by industry executives in both justifying and financing these types of investments.

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Chapter VI

Technology Acceptance and Performance: An Investigation Into Requisite Knowledge

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Organizations expend large amounts of educational and training resources to improve employee task and job performance. These resources must be allocated efficiently and effectively to increase the probability of organizational success. Information technology (IT) is one organizational area in which education and training are particularly important, largely because IT has redefined the requisite skills for functional competency in the workplace. Through an empirical study, this research investigates how knowledge bases contribute to subjects' attitudes and performance in the use of a CASE tool in database design. The study identified requisite knowledge bases and knowledge base interactions that significantly impacted subjects' attitudes and performance. Based upon these findings, alternatives are provided to management that may help organizations increase the performance benefits of technology use and promote more positive attitudes towards technology innovation acceptance and adoption. By structuring education and training efforts to increase performance and enhance positive attitudes, organizations will be better able to optimize their investments in information technology innovations.

INTRODUCTION

Improving human performance in organizational tasks remains a primary goal for modern organizations to increase competitiveness. Goldstein (1993) estimated that organizations invest close to $40 billion in training per year. Within the Fortune 500 companies, 44% of their training investment relates to technical training (Goldstein, 1993). Organizations expend tremendous resources to improve employee task and job performance. Education and training are principal tools used to improve human performance and promote better decision making. In fact, many scholars argue that education and training are the main issues that need to be studied to understand human decision-making and problem-solving behavior. Indeed, Rouse and Morris (1986) observed:

> To the extent that it is reasonable to characterize any single issue as the central issue, this issue is instruction and teaching. For any particular task, job, or profession, what mental models should people have and how should they be imparted? (p. 357)

This statement suggests two significant implications for organizational success. The first implication acknowledges that individuals must have relevant knowledge bases to perform a work-related task or job competently. The second implication addresses the problem of how to identify these knowledge bases so that organizations can facilitate the necessary knowledge transfer. An individual's knowledge base refers to the mental model or structural representation stored in long-term memory about a specific domain or process. Many of the activities surrounding the completion of a job or task are influenced by the individual's relevant mental models or knowledge bases related to that domain or process (Goldstein, 1993; Perrig & Kintech, 1985; Shaft & Vessey, 1995).

Information technology (IT) is one organizational area in which education and training are particularly important, largely because IT has redefined the requisite skills for functional competency in the workplace (Goldstein, 1993; Todd, McKeen & Gallupe, 1995; Zuboff, 1985). In many cases, knowledge of how to complete the relevant task–task-domain knowledge–is essential, but not sufficient, for an individual to perform well in the workplace (Todd et al.). Frequently, the individual must also possess competencies in the use of IT to be successful in modern work environments. It is anticipated that the changes in job competencies resulting from technology shifts (e.g., computer-assisted software engineering; CASE) will increase the cognitive complexity for the worker (Goldstein, 1993). Therefore, in addition to task-domain knowledge, modern workers might also benefit from knowledge bases associated with the use of IT. This study investigates technology acceptance and adoption by examining how an individual's knowledge of a tool, in combination with his task-domain knowledge, influences attitudes and performance related to the use of an IT innovation.

Dramatic improvements in IT price-performance ratios have contributed to the enormous impact of IT on organizational success. One aspect of this impact is end-user computing, a phenomenon that is reshaping the way organizational tasks are performed. Most organizations have implemented personal computers (PCs) and expect their managerial and professional staffs to become proficient end users with this new technology. The potential impact of IT, such as CASE, is increasing as organizations become more information intensive and more end users adopt the automated tools. Cheney, Mann and Amoroso (1986), Davis and Bostrom (1993), Cronan and Douglas (1990), and Sein (1988) indicated that training end users to properly use technology tools to construct their own systems is a critical factor in the successful deployment of IT. This expectation of technology proficiency requires many individuals to rethink their current practices and to learn new methods of task accomplishment (Ryan, 1999). The acquisition of technology proficiency, of course, can be facilitated through education and training. The rapid pace with which organizations are implementing new IT and the tremendous growth of end-user computing are causing an increasing need for subsequent education and training on IT (Goldstein, 1993). Sein (1988) and Bostrom, Olfman and Sein (1988) have noted the importance of a systematic training program to promote successful end-user computing with respect to systems development.

However, there has been very little, if any, study into what should be the focus of this education and training, especially in the use of IT tools that automate substantial portions of work processes like computer-assisted software engineering (CASE), computer-aided design (CAD), computer-assisted instruction (CAI), and expert systems (ES). With IT tools such as these, much of the knowledge about the job requirements (e.g., software engineering in CASE) are embedded in the technology itself. As noted by Goldstein (1993) and Howell and Cooke (1989), increases in technology and machine responsibility may result in increased cognitive demands on people. In such cases, the question becomes "What knowledge is needed by the user to accomplish his or her task while utilizing a process-automating tool like CASE, CAD, CAI, or ES?" Is task-domain knowledge necessary, and if so, what level of proficiency is sufficient? Or is knowledge associated with the systems model and operational procedures of the automated tool required for user satisfaction and enhanced performance? Galliers and Swan (1997) propose that effective IS design must integrate both formal and informal knowledge to promote project success. Goldstein (1993) stated that a systematic instructional program must include training needs assessment based on the related knowledge, skills, and abilities necessary to perform the task. Todd et al. (1995) found various knowledge sources required to perform IS jobs were expanding beyond the traditional skills to include task domain and system knowledge.

The purpose of this exploratory study is to identify requisite knowledge bases and skills that contribute to positive attitudes and improved performance when using an automated IT tool, CASE, to accomplish an organizational task. CASE is a broad group of software technologies that together support the automation of information systems (IS) development and can reduce the programming backlog that has long plagued corporate IS (Loh & Nelson, 1989). The potential impact of CASE is increasing as organizations become more information intensive and the use of CASE technologies becomes more pervasive throughout the organization.

Identifying and understanding how knowledge bases support individuals' IT use will allow organizations to focus educational and training resources more effectively to enhance technology acceptance and adoption (Decker, et al., 1984; Hartog and Herbert, 1986; Zmud & Lind, 1985). Specifically, the research question addressed is: How do particular knowledge bases and skills of users contribute to their attitude and performance in the use of a CASE tool in designing a database for a business application?

THEORETICAL BACKGROUND

In considering the knowledge associated with the use of an automated IT tool like CASE, researchers have identified at least two distinct knowledge bases that are possible (Bostrom et al., 1988; Pei & Reneau, 1990; Sein, 1988). One is a conceptual model that constitutes much of the theoretical foundation underlying the use of the automated tool involved. This conceptual model is closely connected to the methodology embedded in the tool (Hackathorn & Karimi, 1988; Henderson & Cooprider, 1990). In contrast, the step-by-step operating procedures related to the use of the IT tool constitute another possible knowledge base or skill set for an individual (Goldstein, 1993). Past research has provided evidence that, given a sufficiently complex task, knowledge of the tool's conceptual model facilitates superior learning compared to operational knowledge of the IT tool (Borgman, 1986; Eylon & Reif, 1984; Halasz & Moran, 1983). In many cases, the conceptual model is hypothesized to provide an organizational structure for scheduling and controlling the operational procedures related to the tool.

In the Davis and Bostrom (1993) study, contextual knowledge was deemed essential for an individual to achieve meaningful learning. Davis and Bostrom (1990) found that interface designs that are more similar to the user's conceptual model were both easier to learn and more productive. Investigating training needs for end users, Davis and Bostrom found that the ability to acquire new knowledge was strongly influenced by previously established knowledge. They stated that technology-related cognitive demands that are anchored to preexisting knowledge structures are more meaningful, reliable, and retrievable. In a related study, Gasson (1999) found that the form used to represent task-domain knowledge was critical to system effectiveness. Knowledge representation in forms using terms with meanings more familiar to the user is proposed as a superior design methodology approach. Zigurs and Buckland (1998) develop a framework for investigating group support system effectiveness based in part on task/technology fit.

Shaft and Vessey (1995) investigated the role of application knowledge on computer program comprehension. They found that programmers more knowledgeable in the task domain used a top-down decomposition approach. Programmers who were less knowledgeable in the application domain showed a tendency to assemble their understanding of the program in a bottom-up fashion. The ability to use abstract representations (top-down) is theorized to be associated with a more complex task-domain knowledge base. In an investigation of information requirements determination, Vessey and Conger (1993) found performance improvements among novice analysts with higher levels of task-domain knowledge. The tendency of individuals with higher levels of task-domain knowledge to use a more abstract representation scheme suggests a more elaborately organized task view. Performance improvements of these individuals may be, in part, due to their ability to rely on a more elaborately organized task view.

The importance of task knowledge as a critical component of IT learning and task performance has recently been addressed in the literature. Pei and Reneau (1990) used production rule-based ESs to investigate the impact of memory structure on human problem-solving performance. They considered the users' mental models (i.e., their knowledge bases) of the IT and their task-domain-specific knowledge together as essential components in understanding how IT contributes to decision performance and fosters individual learning. Pei and Reneau explicitly identified knowledge transfer (learning), such as in computer-based training (CBT) systems, as one example of how IT and users' mental models are both critical to understanding complex problem solving. In CBT applications, Pei and Reneau noted that the users' understanding of the ES's meta-knowledge is critical to knowledge transfer. Pei and Reneau investigated the consistency between the structure of the rule-based ES and the users' mental models of the task domain as a moderator of technology-facilitated learning. They acknowledged the pedagogical importance of the consistency between the cognitive aspects of the man-machine interface and prior training (i.e., knowledge base) in the application task domain.

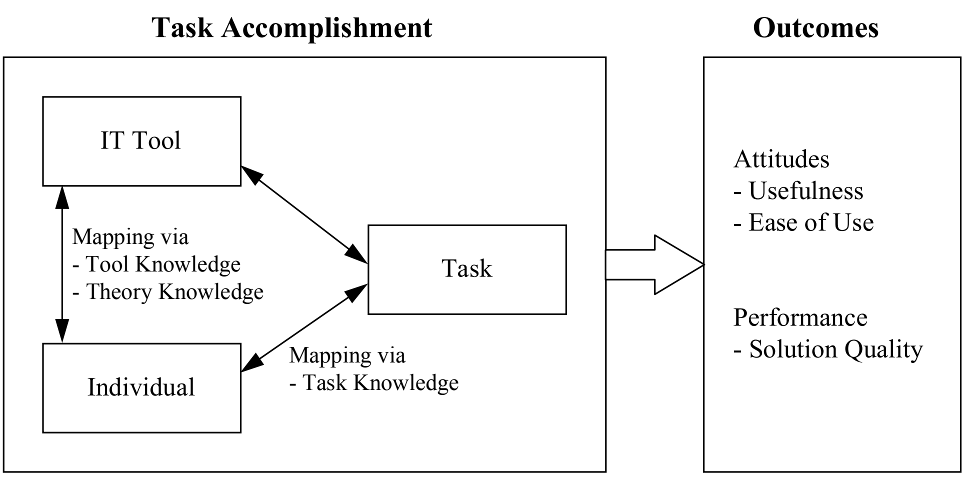
From Pei and Reneau's (1990) study, it is evident that at least two types of knowledge bases, or as they referred to them, mental models, are associated with the use of IT in completing an organizational task. The first is task-domain knowledge, which is a combination of mental structures about the domain itself and the ability to devise problem-solving strategies for that domain. The second, which is directly associated with the use of IT, is the need to develop a mental representation of the automated system to be able to understand and control its behaviors. Hackathorn and Karimi (1988), Henderson and Cooprider (1990), and others have identified the importance of the conceptual model embedded in the tool as well as the operational characteristics associated with the tool. Davis and Bostrom (1993) found that, in sufficiently complex tasks, reference contextual knowledge supports higher levels of performance. Thus, the most effective cognitive process in using automated IT tools is most likely to be the combination of task-domain knowledge along with the conceptual and operational knowledge associated with the utilization of the computer technology.

Bostrom et al. (1988) established an IS research framework that has been used to investigate constructs such as learning theory, conceptual models, mental models, interface effectiveness and teaching methods as they relate to technology attitudes and performance (Davis & Bostrom, 1993; Sein, 1988). In this investigation, the Bostrom et al. (1988) model provides a foundation for studying the impact of particular knowledge bases and skills on the use of a target system during task accomplishment. The discussion identified at least three relevant knowledge bases germane to the use of an automated IT tool like CASE: (1) knowledge about the task, or task-domain knowledge; (2) conceptual knowledge about the theory behind the methodology of the tool, or IT theory knowledge; and (3) knowledge about the procedural steps taken in the use of the tool, or IT tool knowledge. This study investigates these three knowledge bases to determine if knowledge levels are related to positive attitudes and increased performance during task accomplishment. Figure 1 presents the research model.

The attitudinal constructs of perceived usefulness and perceived ease of use utilized in this experiment have been associated with IT innovation acceptance and adoption (Davis, Bagozzi & Warshaw, 1989). Davis et al. (p. 985) defined perceived usefulness as "the prospective user's subjective probability that using a specific application system will increase his or her task performance within an organizational context." They also defined perceived ease of use as "the degree to which the prospective user expects the target system to be free of effort" (p. 985). Davis et al. found that these two constructs affect the acceptance and use of IT. Both perceived usefulness and ease of use were found to be significant factors in people's intent to use computer applications. Their findings were in agreement with those of previous researchers (Barrett, Thornton & Cabe, 1968; Malone, 1981; Schultz & Slevin, 1975). In fact, Davis et al. argued persuasively that many computer satisfaction variables are closely related to the perceived usefulness and perceived ease of use constructs.

The performance variables in this study are measures that are directly associated with the task at hand, that of the logical specification of a database design. The task involved the development of a conceptual schema of a database for a particular application domain. Three of the more important steps in the development of a conceptual schema are: (1) the determination of the primary key or identifier for

Figure 1: Research model



each entity; (2) the specification of the relevant attributes for each entity; and (3) the specification of the relationship or association between two or more entities (Ahrens & Sankar, 1993).

A primary key, or identifier as it is referred to in this article, is an attribute of an entity by which the entity can be uniquely referenced or identified. For example, a student's social security number often serves as the identifier for the student entity in a university database. Attributes are other named properties or characteristics that sufficiently describe an entity. For example, attributes of a student entity other than social security number might be name, address, GPA, and classification. The values of these attributes may or may not be unique among the students in the database. An association is a relationship between two entities in a database. Using a university database as an example, there is a many to many association between the student entity and the class entity. A student may have zero, one, or more classes and a class may have zero, one, or more students.

The IT tool in the experiment is a CASE tool designed to be used by both end users and IS professionals (Dewitz & Olson, 1994a, 1994b). Expertise related to design methodology and CASE technology have been projected as two of the most critical skills to be possessed by IS personnel in the future (Leitheiser, 1992). The use of a CASE tool seems especially appropriate for this study because past research supports the notion, as previously discussed, that users may employ the three knowledge bases (task-domain, theory, and tool) when using CASE. Henderson and Cooprider (1990) began their development of a functional model of CASE technology for IS planning and design by citing the importance of technology being functionally oriented. Hackathorn and Karimi (1988), Welke and Konsynski (1980), and Henderson and Cooprider considered the delineation of methodology and technology tools as paramount to measuring the functionality of design-aid technology. In their view, methodology provides the logical disciplines or theory underlying IS design, and technology tools support the usage behaviors or procedures performed during application development. Sprague and McNurlin (1993) reported that the organizational benefits and user acceptance of CASE are dependent upon the integration of the methodology and technology, that is, upon the theory and procedures.

Baldwin (1993) criticized current CASE tools for failing to include the user's mental model of the application task. Gasson, identified the importance of a methodology that supports both a user's view and a technology view. Adelson and Soloway (1985) found that the designer's formulation of a mental model of the application and the mental simulation of that model are critical components in the successful development of a computer application. A clearly defined mental model is reported to significantly impact the designer's ability to deal with the application at different levels of abstraction. In addition to methodology (theory knowledge) and technology (tool knowledge), Vessey and Conger (1993), Glass and Vessey (1992), Sein (1988), and Fichman and Kemerer (1993) have identified application (task-domain) knowledge as a critical component of successful CASE tool deployment.

Based on the cited research and the above discussion, this study employs a laboratory experiment to examine task-domain, theory, and tool knowledge as determinants of attitudes and performance when using one type of automated IT, a CASE tool. This investigation into determinants of CASE attitudes and performance is justified, in part, by the potential contribution of CASE technology to IS and organizational success (Cheney, et al., 1986; Lee, Trauth & Farwell, 1995; Zmud & Lind, 1985), and the current lack of sufficient theory to guide management in decisions concerning resource allocations to promote greater CASE acceptance and adoption (Goldstein, 1993).

RESEARCH METHODOLOGY

The study utilized a laboratory experiment to address the research objectives. Subjects provided demographics via a questionnaire before receiving a training lecture on a database design CASE tool (Salsa). The Salsa CASE tool, based on semantic data modeling principles (Hammer & McLeod, 1981; Kroenke, 1994), is being developed by a commercial software company with the intention of supporting IS professionals and end users. Semantic data models were developed with the goal to facilitate "the database designer to naturally and directly incorporate more of the semantics of the database into the schema" and provide the database designer and intended user a "natural application modeling mechanism to capture and express the structure of the application environment in the structure of the database" (Hammer & McLeod, p. 352). Two of the more prominent semantic models are Chen's entity relationship (ER) and Kroenke's semantic object (SO; Bock and Ryan, 1993). The semantic object modeling method used in this research consists of identifying: 1) logical objects relevant to the users; 2) attributes that sufficiently describe the logical objects; and 3) associations between objects (Kroenke, 1994). For greater depth of information on the semantic data modeling CASE tool used in this study, see Dewitz and Olson (1994a, 1994b).

Hypotheses

Each hypothesis was analyzed first for interaction effects; in the absence of significant interaction effects, an analysis of main effects was performed. Although the research is exploratory in nature, main effects for tool, task and theory knowledge were all hypothesized a priori to be positive, in the absence of interaction effects. In essence, an increase in either tool, task, or theory knowledge was anticipated to have a positive effect on attitudes and performance. In the presence of interaction effects, there were no a priori research hypotheses. Therefore, attitudes and performance (dependent variables) were hypothesized to be, in part, a consequence of the positive effects of an individual's knowledge bases (independent variables).

Experimental Procedures

The experiment was held in a dedicated instructional computer laboratory. Participants provided demographic data via a questionnaire at the beginning of the experimental session. After a sufficient time for completion of the demographic questionnaire, the subjects participated in a training session on the CASE tool. The length of the training session was approximately 1 hour. The training session included material on the theory of the design methodology, the application of the design methodology (CASE tool), an example case using the design methodology, and a short tutorial addressing the database CASE tool used in this study.

Each participant was provided a hard copy of the case scenario specifying the database design requirements. The subjects were provided ample space to make notes as they used the CASE tool to design their interpretation of the information requirements. During the experiment, subjects were not allowed to consult with each other nor were they able to seek the assistance of the researchers present in the laboratory. Each subject's database design was stored on the computer and was not available to other participants. As a subject completed the database design task, the researcher provided a questionnaire for collecting attitudes regarding database design, the CASE tool, and the design methodology used in the study. In addition, this section of the questionnaire assessed each subject's knowledge of the task domain, IS theory, and CASE tool. The total time required to attend the training lecture, complete the database design task, and provide the personal data was approximately 2 hours. During the course of the experiment no subjects withdrew from the study.

Subjects

The experimental subjects were graduate and undergraduate business students at a major university. Participation in the study was voluntary with incentives of class credit offered to the subjects to increase their motivation. The graduate students were MIS and MBA students enrolled in an MIS course involving end-user computing. The undergraduates were MIS students with varying levels of formal IS education. The research design qualifies as a convenience sample, implying limitations on generalizability beyond the present study. It was anticipated that the subject pool represented a wide variety of IS skill sets. Based on the current research objectives, it was appropriate that these differences exist.

Variable Measurement

The laboratory experiment had three independent variables representing theory, tool, and task knowledge and two classes of dependent variables, attitudes and performance (see Table 1). The independent variables represent knowledge deemed germane to using a CASE tool to perform database design. Attitudes represent a subject's attitudes and beliefs regarding technology usefulness and ease of use. Performance represents the subject's ability to satisfy the information requirements of the design task scenario with an appropriate logical database model.

Table 1: Theoretical model of research variables

Research Variable	Research Variable Surrogate	Variable Type
Task Knowledge	Application Task Comprehension	Independent
Technology Knowledge	IT Tool Competency	Independent
Theory Knowledge	IT Theory Knowledge	Independent
Attitudes related to IT	Attitudes of Perceived Usefulness and Ease of Use when using a CASE Tool	Dependent
Performance related to IT	Performance on database design when using a CASE Tool	Dependent

The independent variables represent the subject's mental model of database design using a CASE tool to perform a database design task. The independent variables measure knowledge of database theory as a contributor to performance, CASE tool competency required to perform the task, and task recall as a surrogate of task-domain knowledge. The knowledge bases were measured through a series of questions. Theory knowledge was measured by the use of nine multiple-choice questions that had been used on examinations in past database classes. Therefore, these questions had been qualified before being used in this study as appropriate items for assessing theory knowledge of database design. The theory questions included topics such as data integrity, domain constraints, and functional dependencies.

Tool knowledge was also measured with nine multiple-choice questions on the operations of the Salsa database design product, the CASE tool used in the experiment. The tool questions addressed the functional competencies required to utilize the CASE product. Tool knowledge questions included operational issues such as system actions required for achieving a specific objective, CASE system function identification (e.g., model validation and attribute grouping), and definitional terms used to express the formalisms inherent in the CASE system.

Task knowledge was assessed by measuring task recall through a series of questions. In task knowledge assessment, subjects were provided with several questions regarding specific facts presented in the database design scenario and were required to identify the correct answer to the question or whether the content of the question was beyond the scope of the scenario. Other task questions required the subject to use free memory recall in identifying specific elements presented in the task. There was a total of nine questions measuring task knowledge.

A subject's scores over the three assessed knowledge bases had a possible range from 0 to 9 each. These scores correspond with the number of questions that a subject answered correctly on the respective set of questions. For example, if a subject answered no questions correctly in responding to the assessment of theory knowledge, his or her score was a 0 for theory knowledge. If someone answered five questions correctly on the tool knowledge set of questions, his or her score on tool knowledge was 5, and so on.

Procedures performed to assure the psychometric qualities of the knowledge assessment component of the instrument (theory, tool, and task knowledge) included evaluations by a panel of MIS researchers and a comparable subject pool of students. Items not acceptable to the expert panel were eliminated, while items were added to adequately represent any constructs identified as lacking in items. The measure of the understandability of the items was assessed using a comparable subject pool. In this manner, evaluating each item on the instrument for clarity and understandability contributed to the validity of the knowledge assessment items. Using ANOVA procedures, items that the comparison group did not consider understandable (i.e., neutral, unclear, or very unclear as opposed to being considered as clear or very clear) with a significance level less than or equal to .039 were eliminated from the instrument.

The attitude measures of usefulness and ease of use were each measured with a set of 5-point Likert questions. Appendix A gives the questions that were used to measure each one of the constructs. These questions were adopted from the study by Davis et al. (1989) with very small modifications (i.e., each of these items was modified to make reference to the specific Salsa CASE tool used by the subjects in the experiment). The Cronbach alphas for the usefulness and ease of use constructs were .935 and .901, respectively.

Performance was operationalized as identifier, attribute, and association specification on the logical level as opposed to the physical level that references the data definition within the database dictionary. The identifier assessed the ability of a subject to specify a logical object and an identifier appropriate for referencing the object. Attribute specification included the attribute by name and its cardinality constraints. The association metric represents the subject's ability to identify relationships between logical objects and specify the necessary cardinality constraints.

Subjects' performance on the database design task was graded on completion. Essentially, task performance represents the designer's achievement of a database schema design free of certain classes of anomalies. A subject's performance was computed for the individual task facets of specifying object identifiers, attributes, and associations. Solution correctness included degree on all task facets (i.e., minimum and maximum cardinality) and appropriate connectivity for the association facet.

The objective grading scheme was designed to provide maximum consistency of scoring. The scheme, as developed in previous research (Batra, Hoffer, & Bostrom, 1990; Bock & Ryan, 1993), classifies errors as fatal, major, medium, and minor for multiple task facets. The grade on a facet ranged from 0 to 4 points, 0 being the lowest grade, or a fatal error, and 4 being the highest, or no error. Grades on facets with medium or minor faults were given scores of 2 and 3, respectively. As examples, the omission of an association was scored as a fatal fault resulting in 0 points; the incorrect connectivity between objects would be scored as a medium error for 2 points; and the incorrect specification of the minimum cardinality of an association would be classified as a minor error for 3 earned points. Since there was a recommended solution containing six objects (and therefore six identifiers), the highest score on performance for the identifier component was 24 (4 times 6). The total number of attributes in the recommended solution was 19, resulting in a total score of 76. Lastly, the total number of associations in the recommended solution was 30 (including minimum and maximum cardinalities), which leads to a high end score of 120.

The task facets were based on the specific methodology used by the CASE tool (see Dewitz & Olson, 1994a, 1994b; Kroenke, 1994). A subject's database design task performance quality was assessed by a trained database researcher and was checked for reliability by consensus agreement between one of the authors and the grader on randomly selected cases. The assessments by the author and grader were the same in almost all cases. Jarvenpaa and Ives (1990) previously used this approach as a means of assuring inter-rater reliability. In comparison to the Jarvenpaa and Ives study, which was less structured in that the grading was content assessment, the present study is more systematically objective and subject to fewer validity threats. Extending beyond the sampling procedures as described, the researchers used a double-blind grading system, which resulted in a minimum 97% agreement between graders.

Task

Subjects were asked to provide a database design suitable to satisfy the information requirements of the presented task scenario. The experimental task had been used in previous research studies investigating database design. The task contained a narrative description and several example reports representing an engineering firm's need to manage project-engineer assignments. Additionally, the task requirements addressed aspects such as firm suppliers and engineer skill certification. The database design task (see Appendix B), although artificial in nature, was deemed a realistic surrogate for practicing database designers based on its use in previous research studies and the specific adaptations made for this study (Batra et al. 1990; Bock & Ryan, 1993). The dynamics of the task content provided a variety of challenges to the participants and included advanced concepts such as supertype-subtype relationships and referential integrity constraints. Prior to the experiment, none of the subjects had been exposed to the database design task. A recommended solution to the database design task was agreed upon by several database researchers prior to the experimental sessions and included the constructs of identifier, attribute, and association specification.

FINDINGS

Data Analysis

Of the 99 participants in the experiment, 53% of the subjects had more than 1 year of business-related job experience. Forty-four percent of the participants reported 1 to 4 years of previous computer use and 56% reported more than 4 years of computer use experience. Twenty percent of the participants classified themselves as graduate students. Based on Rainer and Harrison's (1993) classification scheme for end users, 26 of the subjects classified themselves as novice users (category 1), 51 classified themselves as moderately sophisticated end users (categories 2 and 3), and 20 of the subjects reported being highly sophisticated end users (categories 4 and 5). There were four unusable responses with incomplete questionnaires not included in the analysis, resulting in 95 complete and usable responses.

The study used a series of multiple regression analyses to examine the relationships between the independent variables (tool, task, and theory knowledge bases) and the dependent variables related to attitudes and performance. The multiple regression analysis for each dependent variable was hierarchical, with main effects being introduced first and the marginal contribution of interaction effects examined second. There was no evidence of serious multicollinearity among the main effects. Further, deviation transformations (Neter, Wassermann & Kutner, 1990, pp. 315-329) of the independent variables reduced any multicollinearity induced by interaction and other higher-order terms. Residual analysis did not reveal any significant departures from model assumptions for any of the models but, in the case of perceived usefulness, indicated a curvilinear component for tool knowledge.

Attitudes

Table 2 summarizes the hierarchical development of the final multiple regression model for perceived usefulness and Table 3 contains the sample regression coefficients and their respective individual p-values. Note that in Table 3, the coefficients are in terms of the original independent variable values while the p-values correspond to the transformed variables, thus reducing the potential masking effect of multicollinearity introduced into the model by the higher-ordered terms. The final model includes all terms investigated in the hierarchical process because all smaller models were of diminished quality according to both the C_p and adjusted R^2 criteria (Neter et al, 1990, pp. 446-450). There is strong evidence of interaction effects among the three independent variables in their relationship with perceived usefulness.

As an aid in understanding the nature of the interaction among the independent variables on perceived usefulness, Figure 2 contains an interaction plot similar to that proposed in Peters and Champoux (1979). It appears from this figure that, on average, perceived usefulness increases with tool knowledge for individuals with a match between task and theory knowledge (either having both low task and low theory knowledge [Curve A] or both high task and high theory knowledge [Curve B]). In considering these two groups, those with high task and high theory knowledge (Curve B) evidence higher average perceptions of usefulness than those with low task and low theory knowledge (Curve A).

Table 2: Hierarchical analysis for dependent variable usefulness

Level	Variables	Marginal p-value	Overall R^2	Overall p-value
I	Tool Task Theory	0.00001	0.2403	0.00001
II	Tool*Task Tool*Theory Task*Theory Tool*Task*Theory	0.5436	0.2654	0.0002
III	$Tool^2$	0.0160	0.3115	0.00003
IV	$Tool^2$*Task $Tool^2$*Theory $Tool^2$*Task*Theory	0.00012	0.4570	< 0.00001

Table 3: Regression results for usefulness

Independent Variable	Sample Coefficient	Two-tailed p-value
Tool	-3.050	0.3843
Task	-2.476	0.1248
Theory	-0.822	0.2049
Tool*Task	1.233	0.9539
Tool*Theory	0.536	0.4438
Task*Theory	0.393	0.0039***
Tool*Task*Theory	-0.204	0.0459**
$Tool^2$	0.363	0.0084***
$Tool^2$*Task	-0.136	0.0347**
$Tool^2$*Theory	-0.065	0.0074***
$Tool^2$*Task*Theory	0.023	0.0014***
Legend: *** = p-value < .01, ** = p-value < .05		

R^2 = .4570 Adjusted R^2 = .3883 Overall p-value < .00001

When there is a mismatch between task and theory knowledge, however, it cannot be said that tool knowledge has a positive effect on perceived usefulness. For the group with low task coupled with high theory knowledge (Curve C), average perceived usefulness is high at low levels of tool knowledge but does not appear to improve as tool knowledge increases. On the other hand, for the group with high task and low theory knowledge (Curve D), perceived usefulness appears to increase with tool knowledge to a maximum point and then diminishes beyond that.

Table 4 contains regression results from the main effects model for ease of use. Regression analysis for ease of use produced no evidence of significant interaction. Consistent with the preliminary hypotheses, all sample regression coefficient signs are positive. Further, task and theory each have a significant positive main effect on ease of use.

Figure 2: Interaction plot for perceived usefulness

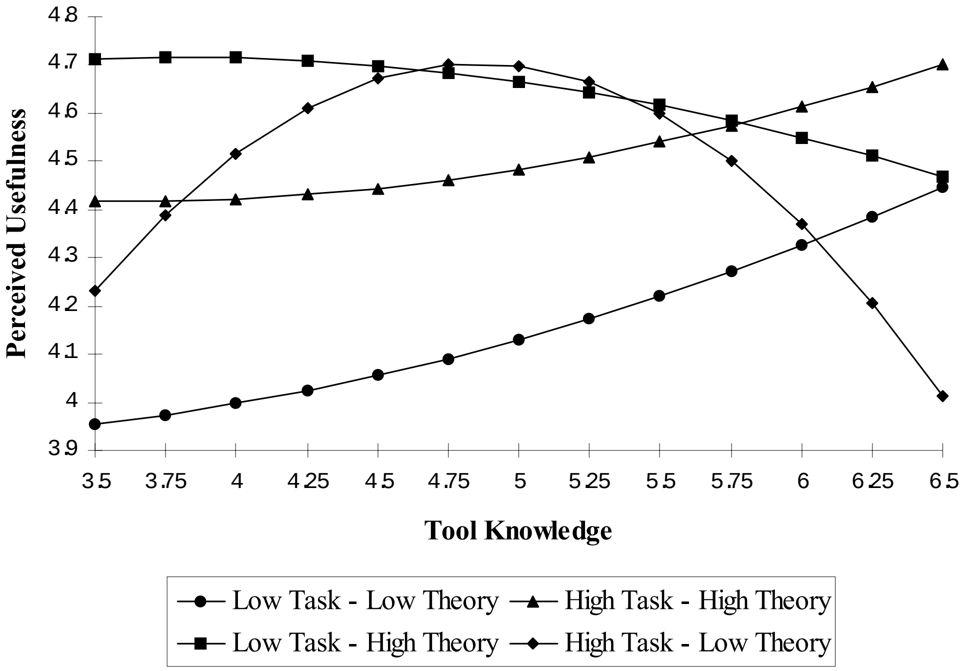


Table 4: Regression results for ease of use

Independent Variable	Sample Coefficient	One-tailed P-value
Tool	0.059	0.0980
Task	0.073	0.0164**
Theory	0.071	0.0071***
Legend: *** = p-value < .01, ** = p-value < .05		

R^2 = .1698 Adjusted R^2 = .1436 Overall p-value = .0005

Performance

Table 5 summarizes the main effects of the regression results for all three performance variables: identifier, attribute and association performance. There were no significant interaction effects in any of these models. In each case, all sample coefficients are positive, and theory has a significant positive main effect. It is interesting to note that in these models which incorporate main effects of tool, task and theory knowledge, theory emerges as consistently significant across all performance facets (identifier, attribute, and association). Also, while not statistically significant, a marginal positive effect of task knowledge is evidenced across the performance metrics. With respect to identifier specification, tool knowledge was marginally significant.

Table 5: Regression results for performance variables

Identifier Performance: R^2 = .1181 Adjusted R^2 = .0891 Overall p-value = .0093		
Independent Variable	Sample Coefficient	One-tailed p-value
Tool	0.821	0.0664
Task	0.564	0.0720
Theory	0.575	0.0410**
Attribute Performance: R^2 = .1259 Adjusted R^2 = .0971 Overall p-value = .0064		
Independent Variable	Sample Coefficient	One-tailed p-value
Tool	1.423	0.1506
Task	1.278	0.0950
Theory	1.979	0.0094***
Association Performance: R^2 = .1391 Adjusted R^2 = .1107 Overall p-value = .0033		
Independent Variable	Sample Coefficient	One-tailed p-value
Tool	2.391	0.1820
Task	2.559	0.0853
Theory	4.228	0.0045***

Legend: *** = p-value < .01, ** = p-value < .05

DISCUSSION

Users' perception of technology as useful is based on the interacting combination of tool, task, and theory knowledge. Davis et al. (1989) identified usefulness as the primary indicator of the acceptance and adoption of technology by individuals, so the findings on this construct are especially important.

As a research construct, perceived usefulness was designed to assess a variety of extrinsic motivators closely related to task performance (Davis et al. 1992). Finding knowledge interaction for usefulness is congruent with the original premise that perceived job performance is a consequence of multiple extrinsic factors and is therefore a complex phenomenon. Usefulness, as a construct, requires that an individual have the appropriate level of theory to formulate the task solution strategy and the complementary competency to use the tool to execute the strategy. When there is a consistent fit between theory and task knowledge (i.e., both high or both low), increasing tool competency increases perceived usefulness. Individuals with strong knowledge profiles in this combination should have receptive attitudes toward the usefulness of a particular technology in accomplishing their tasks. When there is an inappropriate fit between theory and task knowledge (i.e., one knowledge base is high while the other knowledge base is low), increasing tool competency has a dysfunctional effect on perceived usefulness. Instances where the individual possesses high task knowledge without the matching level of theory knowledge are most susceptible to decreasing perceptions of usefulness. This decrease in perceived usefulness may be an indication that the individual lacks the knowledge to develop and apply an overall strategy to solve the robustly perceived task using the IT tool. Instances where the individual possesses high theory knowledge and low task knowledge also showed decreasing levels of perceived usefulness. Individuals in this class may not perceive the task as robust enough to require the IT support tool (i.e., these individuals may perceive themselves as capable of solving the task without the intervention of technology support).

When considering perceived usefulness as an indicator of innovation acceptance and adoption, organizations should strive to establish the appropriate knowledge fit. Organizations should focus their education and training efforts on creating the appropriate knowledge bases sufficient for individuals to perceive technologies as useful in their work. Recognizing the more complex nature of perceived usefulness, organizations must simultaneously consider both theory and task knowledge. Organizational education efforts, such as internal and external continuing education courses, professional educational requirements or certifications, and support for advanced degrees, could be targeted at increasing IT theory knowledge bases. Training efforts such as seminars, hands-on tutorials, and the utilization of information centers could be aimed at increasing tool competencies and task comprehension.

Increasing an individual's task and theory knowledge, on average, increases perceived ease of use. Individuals with high task and/or theory knowledge have the ability to employ the technology with perceived ease of use. In Vessey and Galleta (1991) and Perrig and Kintech (1985) problem solvers are hypothesized to induce their mental models based on the task and/or the problem representation. In these findings, users with sufficient task and/or theory knowledge were able to operate the tool without expending great effort. When compared to usefulness, there is a more simple relationship between ease of use and the supporting knowledge bases. Organizational efforts that focus on either of these knowledge bases can be applied to enhance perceived ease of use. Rotating job responsibilities, work groups or teams, employee empowerment, and increased education and training on the task will contribute to increased task knowledge. Organizations may choose the alternative of heightening task knowledge as a basis for creating higher levels of perceived ease of use of IT in instances where there are obstacles to education and training efforts for IT theory.

It is prudent however, to note that some amount of training in the technology is still a requisite for perceived ease of use. With reference to the specific CASE tool used in this study, this training would be minimal because the semantics of the task are embedded in the semantic data model. Perceived ease of use as a function of task knowledge may be an indication of the transparency of the tool. That is, the effort to employ the tool is minimal for individuals who are more knowledgeable in the task domain. Tool transparency, such as this, suggests that the technology has effectively simplified the man-machine interface such that the cognitive effort may be associated with the task requirements alone. In essence, the tool provides a feeling of naturalness or intuitiveness for individuals well versed in the task domain. Theory knowledge as it supports ease of use suggests that individuals who understand the systems model of the tool may have a greater ability to use the tool without significant effort. Technology innovations where perceived ease of use is associated with task-domain and theory knowledge may require less training than other technology-based tools demanding more tool-specific knowledge for ease of use. In these instances, technology transparency lessens the educational and training effort focusing on tool operations.

Users' performance is significantly improved by increasing theory knowledge. The ability of an individual to specify the identifier facet of database design is positively related to theory knowledge. Attribute and association facets are also supported by similar knowledge profile requirements. The data suggest that individuals with higher theory knowledge perform better on these facets. The CASE tool in this instance may be more intuitive and feel more natural to individuals with sufficient theory knowledge. As a research construct, theory knowledge represents the individual's understanding of the technology's underlying systems model. This is in agreement with findings where performance advantages are associated with the ability to use abstract representation schemes. In these findings there is evidence that increasing theoretical knowledge bases improves the average performance of individuals with a given level of tool and task knowledge. Without evidence of interaction effects or multiple main effects on performance, there is less support for simultaneous training in knowledge bases beyond theory. Again, pragmatically it is necessary that individuals have some level of knowledge in tool and task domains to support adequate performance.

In general, based on these findings, organizations may want to focus their educational and training programs to be more effective by making sure that IT theory knowledge is included in any educational and training program. When considering acceptance and adoption attitudes, organizations should recognize that perceived usefulness requires an appropriate fit between knowledge bases, including IT theory knowledge. Although with perceived ease of use and performance the mix of knowledge bases are not as clear, it is clear that IT theory knowledge should be part of that mix. With these findings, organizations can set attitudinal and performance objectives and design their education and training programs accordingly. Individuals who are well versed in IT theory (knowledge of database in this study), on average, can be expected to perform better on facets related to CASE tool usage and, probably, similar automated IT tools. In fact, this finding implies that knowledge of the procedural operations of CASE or other automated IT innovations may not be sufficient to heighten performance. Based on the findings in this study, users of automated IT innovations (e.g., CASE, CAD, CAI, ES) may develop more positive attitudes and experience performance benefits from knowledge in the methodology and theory embedded in these tools.

CONCLUSION

Individual learning is critical for organizational success. Consequently, organizations must invest in efficient and effective education and training methods for their employees to facilitate the learning process and increase organizational chances for success. These methods should not only present the opportunity for employees to gain new knowledge, but should leverage their current knowledge. If organizational education and training methods are sound, individual learning will result in improved attitudes and competencies.

The alternatives presented in this study should enable organizations to assess new information technologies more accurately. In addition, organizations should be able to more effectively focus on knowledge that promotes positive attitudes and higher levels of technology competencies. The improved attitudes will result in increased acceptance and adoption of new technologies and the enhanced competencies will result in improved performance.

One of the most critical findings in this study was the emergence of the importance of IT theory knowledge in the use of the CASE tool. Casual observations of the educational and training practices of most companies give the impression that they are mainly concerned with imparting knowledge about the work task and knowledge about procedural aspects of IT tools. Rarely it seems that education and training in companies concentrate on cultivating the IT theory knowledge of workers. The trend toward embedding many of the functions of IT development and use in the IT tool itself is accelerating. This trend is not only for CASE, but also for many common office IT products like spreadsheets. With such automation, there might be a tendency now to avoid the theory behind these IT functions. This study indicates that to ignore the theory behind these IT functions in educational and training programs is a mistake. Whether these IT functions are integrated within an IT tool or not, it is still important for users to understand the theory behind them if acceptance and performance are to be optimized.

Other research that has been reported on using automated tools, such as expert systems, in education and training shows that automated tools cannot simply be made available to the end users and learning will occur (Clancy, 1983). To create an effective learning environment, other components are necessary. This study found that one of those components is the theory behind the methodology embedded in automated IT tools like CASE. Future research should continue the line of investigation developed in this study so the potential for successful deployment of IT (e.g., CASE) will be improved.

APPENDIX A

DEPENDENT VARIABLES

ATTITUDES

Useful

The SALSA tool would allow me to work more quickly.
The SALSA tool would increase my job performance.
The SALSA tool would increase my productivity.
The SALSA tool would make me more effective in my job.
The SALSA tool would make my job easier.
I would find the SALSA tool very useful.

Ease of Use

The SALSA tool is easy to learn.
The SALSA tool is controllable.
The SALSA tool is clear and understandable.
The SALSA tool is flexible to interact with.
The SALSA tool is easy to use.
It is easy to become skillful on the SALSA tool.

PERFORMANCE

Identifier: Primary key specification of primary and secondary keys for logical object reference.

Attribute: Specification of properties that adequately describe the logical object. Includes minimum and maximum cardinality.

Association: Specification of relationships that adequately describe the associations between logical objects. Includes minimum and maximum cardinality.

INDEPENDENT VARIABLES

Theory Knowledge: Assessment of theoretical database knowledge.

Tool Knowledge: Assessment of CASE tool comprehension and functional competency.

Task Knowledge: Comprehension of task scenario describing application information requirements.

APPENDIX B

DATABASE DESIGN CASE

Engineering Services Inc.

Engineering Services Inc. is an engineering firm with approximately 500 employees. A database is required to keep track of all employees, employee skills, employee department assignments, and supply vendors for departments.

Every employee has a unique number assigned to them by the firm. It is also necessary to store their name and date of birth. Each employee is given a current job title (e.g., engineer, administrator, foreman, etc.). Additional information recorded for engineers only includes their type of degree (e.g., electrical, mechanical, civil, etc.), certification date, and certification expiration date (Exhibit A). Information recorded exclusively for administrators includes typing speed (Exhibit A).

There are 11 departments and each department has a unique phone number. Employees are assigned to only one department and departments usually have many employees. Each department deals with many vendors (Exhibit B). Typically, a vendor deals with more than one department (Exhibit B). Storage of the name and address of each vendor is also required. The date of the last meeting between a department and a vendor also is required to be stored.

An employee can have many skills (e.g., drafting, project estimation, safety inspection, etc.). Each skill category has at least one employee capable of providing that service. Skill information consists of a skill code and a short skill description.

Exhibit A

Employee Report

As of July 31, 1993

EmployeeID	Name	Date of Birth	Job Title	Specific Data	
123	Jack Shuster	12/03/65	Engineer	Civil	Cert. 1991, Expires 1994
611	James Bloch	11/23/68	Engineer	Mechanical	Cert. 1988, Expires 1994
1212	Jay Smith	01/01/44	Engineer	Mechanical	Cert. 1978, Expires 1995
1310	Jay Spence	09/22/77	Administrator	55 WPM	
1677	Sid Galloway	02/23/67	Administrator	44 WPM	
2121	Jackson Titus	03/31/73	Engineer	Electrical	Cert. 1989, Expires 1996
3001	Rob News	04/22/76	Foreman		
3010	Peter Hardway	05/09/74	Engineer	Electrical	Cert. 1990, Expires 1995

Exhibit B

Department Vendor Contact Report

For the Month of: July, 1993

Department	Supply Vendor	Contact Date
Electrical	Johnson Supply Co.	7/1/93
	Interstate Wholesale, Inc.	7/11/93
Mechanical	Pipe Fabricators	7/2/93
	Commercial Supply	7/8/93
	Interstate Wholesale, Inc.	7/11/93
	Hi-Vac Mfg.	7/23/93
Drafting & Design		
Repair & Maintenance	Interstate Wholesale, Inc.	7/11/93
	Parts Inc.	7/23/93

Summary Vendor Contact Report

Vendor Summary	Department
Johnson Supply Co.	Electrical
Interstate Wholesale, Inc.	Electrical Mechanical Repair & Maintenance
Pipe Fabricators	Mechanical
Commercial Supply	Mechanical
Hi-Vac Mfg.	Mechanical
Parts Inc.	Repair & Maintenance

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Chapter VII

Motivations and Perceptions Related to the Acceptance of Convergent Media Delivered Through the World Wide Web

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The convergence of entertainment and communications media in broadband World Wide Web delivery channels promises to provide modern consumers with a wealth of information and data utilities in the home. Best evidenced by the impending synthesis of media content and media delivery in the form of the AOL/Time Warner merger, this developing innovation of a single-channel rich content information utility in the household suggests the need for understanding the complex and diverse motivations attendent to the adoption of new media and new technology merged into a single commercial entity. The purpose of this chapter is to examine the well-understood technology adoption precepts of the technology acceptance model (cf., Davis, 1989; Venkatesh & Davis, 1996; 2000) in concert with the media-use motivation theories arising from adaptation of the uses and Gratifications (U&G) perspective, with particular emphasis on the emerging effects of social gratifications for Internet use.

INTRODUCTION

Modern society is structured based on information and communication (Ball-Rokeach & Reardon, 1988; Rogers, 1986), and as society evolves in its use of information resources, recent mergers of media and communications interests herald a new stage in the evolution of the information utility we know as the Internet. As society evolves, media will also evolve from mass exposure to interactive communications, and this interactive model leads futurists to predict that the Internet will become the primary delivery medium for society's combined entertainment, communication and information needs (Stafford & Stafford,1998). These futuristic predictions did not seem particularly imminent until the recent business revolution represented by the AOL/Time Warner merger.

What was once a strictly academic information utility is now a powerful commercial and consumer venue. Businesses are exploring the potential of the Internet for promoting and consummating business transactions, but the multi-faceted nature of the Internet also raises questions about how commercial information, communication and entertainment services can be delivered in new ways (Peterson, Balasubramanian, & Bronnenberg, 1997). Technology gives us the capability to converge media channels and content on the Internet, but do we really appreciate the implication that convergence provides for the ways in which business may or even should change as a result?

INTERCONNECTED NETWORK OR META-MEDIUM?

The Internet evolved as an "international interconnection of computers" (Simon, 2001). In that role, it certainly functions as a computer network should, providing information-based services to connected users. But it has also been used as a platform for experimentation with broadband communication channels and streaming technology for delivery of the rich media files, and in this sense, the Internet goes beyond a computer network and becomes an entertainment channel. However, with the capability to deliver rich media entertainment services such as audio, video, and integrated telephony also under investigation by industry, the Internet can also be thought of as possessing the characteristics of a commercial medium. Indeed, the modern Internet at once subsumes the characteristics of a telecommunications transmission medium with the multifaceted aspects of the rich media channels and content delivered over the transmission medium (Stafford & Stafford, 1998, 2001).

The Internet has always been a medium for communication; its culturally understood role in the past has generally been that of a computer network that facilitates the sorts of information exchanges that academic computer users wish to engage in. The emerging Internet, though, is more than a global information utility for scientists. As consumers adopt Internet technology for their own purposes and needs, the Net also becomes a more mundane consumer entertainment source. As a telecommunications utility in the consumer market, it also begins to develop the capability to replace or supplement well-known and familiar communications and entertainment media such as telephones, radio and television. In this sense, the Internet is evolving toward the role of meta-medium.

The Internet is a largely commercial transmission medium that delivers multiple content-based media. We could coin the term "meta-medium" to characterize this multichannel capability of the interconnected network. To that end, the emerging role of the Internet we now know in the information-enabled society of the near tomorrow is a key focus of this chapter.

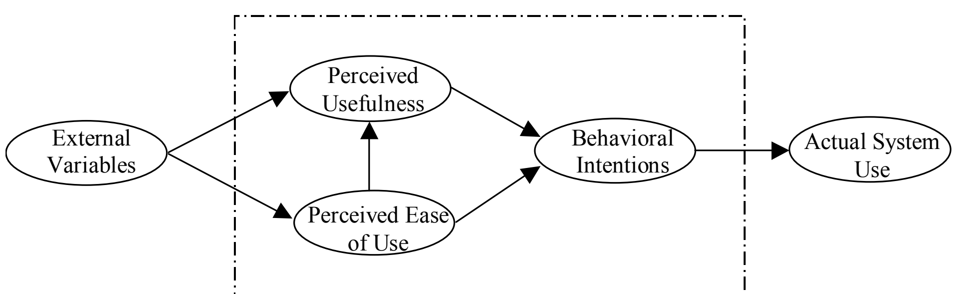
UNDERSTANDING META-MEDIA

Experts agree that the primary impediment to realizing maximum potential for converged multimedia delivery is communication bandwidth (Burke, 1997; Gupta, 1997; McDonald, 1997), but the AOL/Time Warner merger and subsequent speculation about AOL/Time Warner interest in acquiring additional broadband telecommunications properties may well resolve this issue in most of the consumer market. In fact, with bandwidth now growing faster than chip speed, the general issue may soon be moot (e.g., Roche, 2002).

However, no work has been done to determine how consumers will react to the availability of this new media modality. Investigations of rich media delivery to the home via converged Internet channels should also include a consideration of consumer motivations to seek and commercially embrace converged media content. The question is: will consumers adopt the Internet as a single point of distribution for their combined information, communication and entertainment service needs?

The Technology Acceptance Model (cf., Davis, 1989; Venkatesh & Davis, 1996, 2000) is one useful theoretical perspective for diagnosis of consumer readiness to use technical media for mundane entertainment purposes. The basic form of the Technology Acceptance Model (TAM), as developed in Venkatesh and Davis (1996), is shown in Figure 1.

Figure 1: The technology acceptance model of Venkatesh and Davis (1996)



In the TAM research, there has been a call for better understanding of the antecedents to technology use and adoption (Venkatesh & Davis, 1996, 2000), but there are precious few theoretical perspectives in the MIS literature, other than TAM, that can be utilized to understand consumer decisions to use new entertainment technologies. The Uses and Gratifications (U&G) theory of mass communication and media adoption has been widely and successfully used in consumer market studies of new media adoption numerous times in the past (Stafford & Stafford, 2001). While the emerging converged Internet bears only passing resemblance to television, U&G was useful in helping researchers understand how television, when it was a new technological innovation, was adopted by consumers. U&G has also been similarly applied to examinations of follow-on innovations like remote controls and VCRs (e.g., Stafford & Stafford, 1998)

TAM has generally investigated new technology use from a systems standpoint, applying the perspective of the decision to use certain corporate resources by employees; however, in conceptualizing the Internet as a consumer-adopted communications and entertainment medium, investigations of adoption necessarily must consider not only systems perspectives but also media considerations. Since U&G dimensions are useful to predict use and benefits arising from use of [technological] media, they appear to have great promise for testing in the role of putative antecedents to the key TAM constructs of perceived usefulness and perceived ease of use.

The Internet *Is* the Medium

In the communications literature, scholars generally agree that the Internet is an instance of media (e.g., Eighmey, 1997a; 1997b; Newhagen & Rafaeli, 1996; Rafaeli, 1988; Stafford & Stafford, 1998; 2001). That is to say, the Internet has evolved beyond its obvious and primary utility as a data communications network and is taking on characteristics of mainstream consumer market commercial media, like television or radio, in the converged delivery of data, entertainment and content to the household.

The Uses and Gratifications theoretical perspective evolved from the study of the television medium decades ago (e.g., Katz, 1959; Klapper, 1963; McGuire, 1974), but it is being applied today, as it has in the past, to the new media of our day (e.g., Eighmey, 1997b; McDonald, 1997; Newhagen & Rafaeli, 1996; Peterson et al., 1997; Stafford & Stafford, 2001). Hence, U&G theory has cogent applications in media use research focused on the converged Internet.

Uses and Gratifications, Now and in the Past

In the U&G view, motivations for media use tend to be split between the processes of media use and the content of media carriage; these are known as process versus content gratifications (Cutler & Danowski, 1980). The preference for what a medium carries is content-related (i.e., a content gratification). This can be demonstrated with the analogy of television viewers who only watch the nightly news to learn about local events, but viewers who use their VCR or TiVo unit to record shows in order to enjoy using the program manipulation features of the recording technology, such as fast-forwarding or deletion of commercial breaks during later viewing, are motivated by the actual use of the medium–which is a process gratification (e.g., Stafford & Stafford, 1998).

Although U&G theory was developed in studies of the infant television medium, it can be diagnostic in understanding consumer motivations for using the Web (Newhagen & Rafaeli, 1996; Rafaeli, 1988). Using Internet terminology, some people may enjoy the process of randomly browsing the Web just for fun (Hoffman & Novak, 1996), while others may be motivated to seek specific informational content carried by a given Internet site (Stafford & Stafford, 1998). Those who surf just for fun are process-oriented, and those who log on and go directly to a commercial site for their stock quotes are content-oriented.

There are indications that Internet users may be strongly motivated by content in their choice of specific sites to visit (Drèze & Zufryden, 1997; McDonald, 1997; Stafford & Stafford, 1998). The well-known psychologist William McGuire (1974) believes that holding power is the key to sustained media use. One should be less concerned about how a user came to a medium than about understanding how the medium could hold a user once browsing had its intended effect of capture. Internet scholars also think about holding power with regard to Web site content (Barker & Groenne, 1997).

In some views, the Web simply serves as an additional technological tool to be integrated with traditional promotional elements of the marketing mix (Peterson et al., 1997; Philport & Arbittier, 1997). If so, then it appears that the process and content gratifications dichotomy developed in television studies should be a very useful framework for understanding Internet media use. Yet, if Internet site and service operators could identify something beyond simple browsing and site content to attract and motivate user loyalty, this might represent a potent differentiator between operators within the Internet medium as well as between the Internet and conventional promotional media.

Social Gratifications

The "active audience" tenet of uses and gratifications theory (e.g., Katz, Blumler & Gurevitch, 1974; Rubin, 1981) is important to understand in Internet contexts. Active audiences are selective and make their own choices (Levy & Windahl, 1984); they might be expected to use Internet media to their own personal ends, to paraphrase early renditions of the active audience principle (e.g., Klapper, 1963). In other words, people are not passive users of the Web; they get involved and interact with it in ways that extend beyond traditional media models of one-way mass exposure. Hence, understanding the activities prized by audience members is critical, since these activities are representative of the underlying motivations that influence selective and individual site access (Stafford & Stafford, 2001).

While previous U&G research has focused on the standard dichotomy of process and content gratifications, a key finding of current Internet U&G research suggests strong social uses and gratifications for Internet use (Stafford & Stafford, 2001). This is an important finding. While the process gratification corresponds nicely to enjoyment of the browsing process of Web surfing, and content gratifications have been referenced handily to the utility of online information sources, the social dimension of Internet media represents a significant divergence from the understanding of media previously studied in the U&G paradigm. Perhaps we intuitively realize that the Internet is a social venue, since we use it for email and chat activity, but there is little theoretical structure to base this intuition on.

To the extent that there is any other social factor identified in the Internet use literature, it appears that the Technology Acceptance Model research is also beginning to identify social components to technology adoption (e.g., Venkatesh & Davis, 2000). For that reason, the role of social motivations for use in technological media, in addition to more standard content and process U&G dimensions, could perhaps be related to key TAM constructs such as Perceived Usefulness in meaningful ways? A close examination of the technology acceptance literature readily identifies instances in which various combinations of standard process and content gratifications, as well as special instances in which the unique social gratification can be expected to be predictive antecedents to some of the well-established TAM constructs.

CONSUMER ACCEPTANCE OF INTERNET TECHNOLOGY

Business adoption of new technology is well understood from the TAM perspective, but consumer adoption of new computer technology has not been widely studied. Previous TAM research has noted the need for understanding the antecedents to Perceived Usefulness (cf., Bagozzi, Davis & Warshaw, 1987; Venkatesh & Davis, 2000), and scholars have noted that other media-related theoretical models could be useful to consider (Venkatesh & Davis, 2000, p. 200). This suggests a role for well-developed dimensions of Web use and Web user motivation based on the U&G paradigm (e.g., Stafford & Stafford, 2001). Comparisons of the two theoretical perspectives, technology acceptance and uses and gratifications, could lead to the development of user motivation profiles to form an emerging model of Internet media acceptance. This perspective of Internet acceptance could be conceptually grounded in, but theoretically distinct from, the TAM.

Key components of such a model might include expectations for how perceived usefulness in the TAM might interact with robust Internet uses and gratifications profiles developed for the Internet (e.g., Stafford & Stafford, 2001). In terms of the uses consumers might have for the Internet and the motivations for engaging in them, several proposed relationships could be offered. For example, recent findings suggest that heavy users of the Internet are very interested in using it for social interactions (e.g., Emmanouilides & Hammond, 2000; Karahanna & Straub, 1999).

Therefore, it would be expected that leading edge Internet technology adoption might be related to social gratifications for Internet use:

P1: Social gratifications will be primary predictors of Internet broadband multimedia adoption intentions by heavy users of the Internet.

P1a: E-mail use will be significantly related to social gratification among heavy Internet users (e.g., Emmanouilides & Hammond, 2000; Karahanna & Straub, 1999; Stafford & Stafford, 2001; Venkatesh & Davis, 2000).

P1b: E-mail use will be significantly related to Internet use (e.g., Kraut, Mukhopadhyay, Szczypula, Kiesler & Scherlis, 1999).

Experience leads to different expectations for technology, in terms of key TAM constructs. While the usefulness of the technology is always the factor that drives intention to use it, ease of use for the technology can influence user perceptions of usefulness if they are not sure how to make use of it. In other words, the more a user interacts with a technology, the more that the inherent ease of use for the technology will be a distinguishing factor in the user experience:

P2: Perceived ease of use will not be significantly predictive of perceived usefulness among heavy Internet users (e.g., Karahanna & Straub, 1999; Venkatesh & Davis, 1996).

As noted, the literature supports the supposition that heavy users of technology are more interested in what it can do for them than in how easy it is to use, having already mastered the task of learning how to use the particularly technology. Hence, among heavy users, the ease with which technology can be put to use is a minor consideration (e.g., Emmanouilides & Hammond, 2000). This arises from the consideration that heavy users are generally skilled users, so ease of use becomes a moot point in their motivation to use technology:

P3: Social gratifications will be significantly predictive of perceived usefulness among heavy Internet users.

The theoretical relationships explicated in propositions P1, P2, and P3, above, are displayed in Figure 2. In the figure, significant paths are shown in bold, and paths not expected to be significant are indicated by light dashed lines.

There is reason to expect that moderate Internet users will display slightly different behavior with regard to predictability of technology acceptance, as related to proposed U&G antecedents of perceived ease of use in its moderating influence on perceived usefulness. For one thing, inexperienced users are often gratified by the simple experience of successful technology use (e.g., Venkatesh & Davis,

Figure 2: Proposed heavy user Internet acceptance model

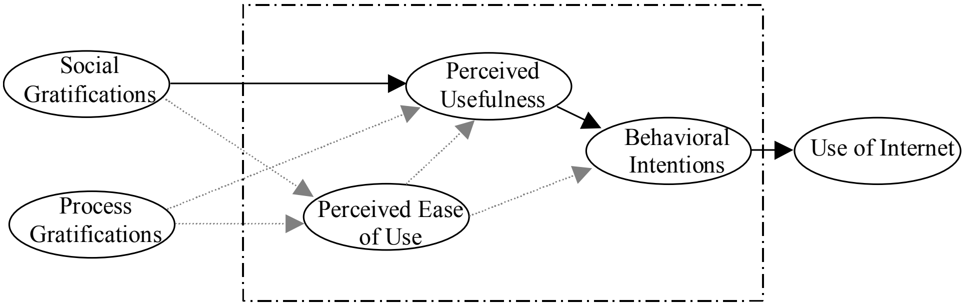
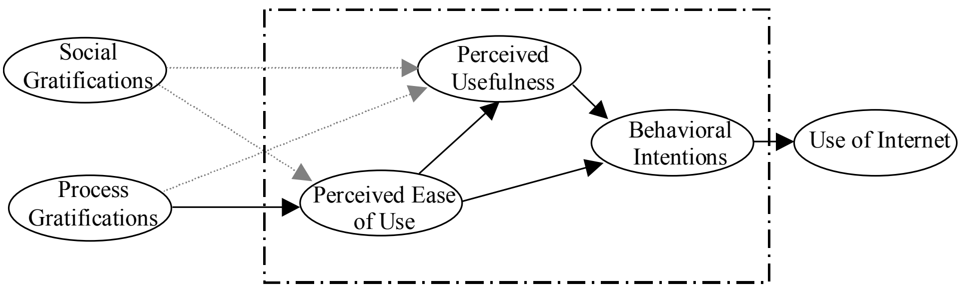


Figure 3: Proposed moderate user Internet acceptance model



1996). To the extent that the familiar TAM moderational relationships beginning with ease of use, continuing to usefulness and resulting in intentions to use technology can be expected to operate, one must expect technology use and perceptions of subsequent utility in use to arise from the expectations that it can be used, among less than heavy users (e.g., Venkatesh & Davis, 1996, 2000):

P4: Among moderate Internet users, perceived ease of use will be dependent upon high degrees of process gratification.

P5: Among moderate Internet users, perceived ease of use will be significantly predictive of perceived usefulness.

The relationships described in P4 and P5, above, are represented in Figure 3.

DISCUSSION

Perceived Ease of Use has been shown in previous studies to be a predictor of Perceived Usefulness, but not necessarily a direct predictor of technology adoption (Davis, 1989; Venkatesh & Davis, 1996). The distinctions between experienced and inexperienced users of Internet technology are important ones, since most of the new growth of commercial Internet services is to be found in the later, less experienced, adopters, going forward. Inexperienced users only develop perceptions of ease of use with time and experience, so the role of PEOU in the TAM could be expected to play a significant role in determining the Internet media adoption practices of many moderate-to-low users (e.g., Venkatesh & Davis, 1996).

However, TAM research has repeatedly emphasized that Perceived Usefulness is the primary factor in determining adoption of technology (Bagozzi et al., 1987; Venkatesh & Davis, 2000). In light of research tangential to the TAM stream (e.g., Emmanouilides & Hammond, 2000; Kraut et al., 1999; Stafford & Stafford, 2001), it appears that U&G dimensions of social use, Internet information content and Internet usage processes may have some value in predicting the effects of Perceived Usefulness on intention to adopt broadband Internet multimedia delivery services from converged providers. For this reason, it seems useful to consider U&G antecedents to the standard TAM structure of constructs.

The impact that social gratifications may have in Internet use decisions appears to be largely a function of user experience, and the general expectation is that heavy Internet service users will be more motivated by social gratifications than will light to moderate users. It may be the case that heavy Internet users develop a preference for that particular medium of communication through repeated exposure to it. Regardless of the reason, heavy users tend to use lots of e-mail and socially linked aspects of Internet services, so to the extent that heavy users are desirable consumer targets for ISPs, this supposition could have valuable implications for practice.

The impact of process gratifications is seen in the opportunity for new business and market share expansions in the ISP business and, by implication, in general e-commerce. The new service users (hence, the potential new online shoppers) will be the growth market for the ISP business, since heavy users are earlier adopters with previously established preferences. Process gratifications are important among moderate users because they are motivated to use technology by the successful process of using it; they enjoy and benefit from easy-to-use technologies, and business can make inroads by offering interfaces and applications that are easy to learn and use or by providing ready access to user training and assistance for technologies that are more complicated.

Combining a media view of the Internet with a technology view can be useful. The U&G perspective has already been demonstrated to be effective for the study of Internet use (e.g., Eighmey, 1997b; Newhagen & Rafaeli, 1996; Rafaeli, 1988; Stafford & Stafford, 1998, 2001), and its application to the investigation of converged media on the Internet is particularly useful in combination with seemingly related TAM constructs, since the TAM has not, so far, been demonstrated in media-related contexts. In considering the converged multimedia Internet of the near future, we can easily think of the Internet as "new media." Hence, it becomes quite logical to combine the computer technology acceptance measures of TAM with the robust findings of the U&G literature in order to properly understand the consumer's propensity to adopt this new technology-based medium.

To the extent that the Internet is to succeed as a new consumer market shopping venue and not just a broadband media delivery vehicle, researchers and the practice alike must begin to understand the forces that bring new customers to Internet service. Because, when consumers begin using the Internet, even if only for mundane entertainment purposes, it is surely only a matter of time and accumulated experience before they become reasonable targets for B2C commercial activity online.

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Chapter VIII

Key Issues in IS Management in Norway: An Empirical Study Based on Q Methodology

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Information systems (IS) departments face many challenges in today's rapidly changing environment. One approach to understanding these challenges is to survey IS managers to elicit what they consider are key issues. Studies of key IS management issues have been conducted for some years in many nations and regions. However, most of these surveys lack a theoretical basis for the selection of key issues. Furthermore, most studies have used a single-round or a multi-round Delphi method. This paper provides an overview of research approaches to key issues studies combined with key issues results from previous research. The paper presents methodological issues and choices for a survey on key issues in IS management which was conducted in Norway. A three-step procedure for key issues selection is introduced, and a Q-sort analysis is adopted. The paper presents results from the Q-sort survey and analysis. The highest ranked key issue in Norway, according to the survey, is concerned with improving links between information systems strategy and business strategy.

INTRODUCTION

Information systems (IS) departments face many challenges in today's rapidly changing environment. One approach to understanding these challenges is to survey IS managers to elicit what they consider are key issues. According to Niederman,

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Brancheau and Wetherbe (1991), the primary purpose of such studies is to determine the IS management issues expected to be most important over the next 3 to 5 years and thus most deserving of time and resource investment.

This paper provides an overview of research approaches to key issues studies and presents methodological issues and choices for a survey on key issues in IS management which was conducted in Norway in 1998. A three step procedure for key issues selection is introduced, and a Q-method analysis is adopted. Finally, the paper presents results from the Q-sort survey and analysis.

LITERATURE REVIEW

This research is concerned with key issues selection procedure and key issues survey approach: it is assumed that the ranking results of the studies presented above were influenced by selection procedure and survey approach. The most common selection procedure is to start with an old key issues list and let it be revised in multiple survey rounds as shown in Table 1. Some studies start from scratch by asking respondents to specify issues that they think will be key issues. The most common survey approach is the Delphi technique as shown in Table 1. Some studies apply other methods. This research applies Q-sort that already has been used in Brazil by Morgado, Reinhard and Watson (1995, 1999).

KEY ISSUES SELECTION

Some key issues appear to emerge quickly. The sudden prominence of business process redesign in many recent studies (e.g., Brancheau, Janz & Wetherbe, 1996) indicates that IS managers may be too willing to respond to a current hot topic, and their attention may be too easily diverted from fundamental, long-term issues. If asked in 1998, many Norwegian IS managers would probably rank “Year 2000” as a key issue. The Year 2000 issue was, however, both a short-term problem and an issue that is part of the larger problem of maintaining software. Hence, the selection of key issues for survey research is associated with several problems as listed in Table 2.

The lack of theory is a major concern. Watson, Kelly, Galliers and Brancheau (1997) suggest that a sufficiently relevant theoretical model on which to base a new key issues framework should be identified. They discuss role theory, managerial IS competencies and general management practices as “redesign” approaches to potential new key issues frameworks (Watson et al., p. 111).

Advantages of the “redesign” approach include the possibility that the framework be complete, consistent, parsimonious, and both regionally and temporally stable. Disadvantages include the lack of continuity with previous studies and the danger that the issues might become so abstract that they would cease to have meaning to IS managers and executives, thus breaking an important link to practice.

Niederman et al. (1991) made a theoretical contribution by classifying key issues along three dimensions and categorizing them into four groups. The three

Table 1: Comparison of Methodological Choices in Key Issues Studies

Study	**Key Issues Selection**					**Key Issues Survey**
	List	**New**	**Method**	**Respondents**	**Score**	**Nation**
Badri (1992)	Old	No	1 round	CIOs	Rate	Gulf nations
Brancheau et al. (1996)	Old	Yes	Delphi 3 rounds	SIM members	Rate	USA
Burn, Saxena, Ma and Cheung (1993)	Old	Yes	Delphi 3 rounds	Managers	Rate	Hong Kong
CSC (1998)	Old	No	Survey 1 round	IS executives	Rate	USA, Europe, Asia/Pacific
Deans et al. (1991)	Old	Yes	Survey and Interview	MIS managers	Rate	USA
Dekleva and Zupancic (1996)	New	Yes	Delphi 4 rounds	IS managers	Rate	Slovenia
Dexter et al. (1993)	New	Yes	Delphi 3 rounds	IT managers	Rate	Estonia
Galliers, Merali and Spearing (1994)	New	No	Delphi 1 round	Executives	Rate	UK
Harrison and Farn (1990)	Old	No	Survey 1 round	Professionals	Rate	USA Taiwan
Kim, Shim and Yoon (1999)	New	No	Survey 1 round	IS practitioners	Rate	USA
Mata and Fuerst (1997)	Old	Yes	Survey 1 round	IS managers	Rate	Costa Rica Guatemala
Morgado et al. (1995, 1999)	Old	Yes	Q-sort ISM	IT managers	Rank	Brazil
Moores (1996)	Old	No	Delphi 1 round	MIS managers	Rate	Hong Kong
Olsen, Eikebrokk and Sein (1998)	Old	No	Delphi 1 round	IT managers	Rate	Norway
Palvia and Palvia (1992)	Open	Yes	Seminar	Managers	Rate	India
Pervan (1993)	New	Yes	Delphi 3 rounds	IS managers	Rate	Australia
Pollard and Hayne (1996)	Old	Yes	Delphi 2 rounds	IS personnel	Rate	Canada
Swain, White and Hubbert (1995)	Old	Yes	Delphi 1 round	Information manager	Rate	USA
Usman and Stein (1999)	Old	No	Delphi 1 round	IS managers	Rate	Australia
Wang (1994)	Old	No	Delphi 1 round	IT manager	Rate	Taiwan
Wrycza and Plata-Przechlewski (1994)	Old	No	Survey 1 round	Seminar participants	Rate	Poland
This study	New	Yes	Q-sort	CIOs	Rank	Norway

dimensions are management versus technology issues (M/T), planning versus control issues (P/C), and internal versus external issues (I/E). The four groups consist of:

- **Business relationship:** These issues deal with concerns external to the IS department. They focus on managing the relationship between IS and the business. The group includes data resources, strategic planning, organizational learning, IS organization alignment and competitive advantage.
- **Technology infrastructure:** These issues deal with technology concerns. They focus on the integration of technology components to support basic business needs. The group includes information architecture, technology infrastructure, telecommunications systems, distributed systems, and electronic data interchange.
- **Internal effectiveness:** These issues focus internally on the IS function. They are concerned with those essential activities comprising the bulk of the IS function's work. The group includes human resources, software development, applications portfolio, and IS effectiveness measurement.
- **Technology application:** These issues focus on the business application of specific information technologies. The group includes CASE technology, executive/decision support, and end-user computing and image technology.

However, classifying issues into dimensions and categories is a challenging task (Smith, 1995). In Table 3, the latest US SIM classification is listed.

Table 3 can be used to identify both potentially missing and overlapping issues. For example, there are no business relationship issues involving technology, and there are four business relationship issues involving management-control-external. This analysis shows that there are essentially 32 different issues, which are generated by crossing the four categories with the three binary measures (i.e., M/T, P/C, I/E).

The importance of each of the four categories in Table 3 can either be determined by the relative number of issues in the category or by the median ranking of the issues in the category. The table is sorted according to the number of issues in each category. If the median ranking is applied, then technology infrastructure has the median rank of 4.5 (1, 3, 4, 5, 18, 19), followed by business relationships, 10; internal effectiveness, 11; and technology application 13.5. Rankings are ordinal data, and it would be incorrect to compute an average. The correct measure of central tendency is the median.

KEY ISSUES SURVEY

The dominant approach to key issues research is the Delphi method, which uses a series of linked questionnaires. Successive rounds of questionnaires summarize subjects' responses to the preceding questionnaire and ask respondents to re-evaluate their opinions based upon the prior results. The process is continued until a reasonable level of consensus is achieved (Brancheau et al., 1996). However, the Delphi survey approach has some problems as listed in Table 4.

Table 2: Key issues selection problems

Problem	Problem Description
Time	Key issues change over time; critical issues in the early 1990s differ from critical issues in the late 1990s. Therefore, the use of previous key issues lists in new surveys has limitations.
Fashion	The IS profession is notable for its fashion swings. In the last few years the hot topics have included outsourcing, business process redesign, and the Internet.
Events	Certain events strongly influence ranking, for example, the Year 2000 issue.
Overlaps	Some issues are not defined properly and overlap with other issues.
Granularity	While some issues refer to broad general problems, other issues refer to more narrow and specific concerns.
Theory	Application of theory is lacking in key issues selection.
Clarity	Some issues are not formulated and communicated properly to enable respondents to understand the contents of the issues.
Causality	Some issues might, although ranked as unimportant, represent important drivers of other key issues. For example, recruiting and developing IS human resources might be an important driver of building an IT architecture.
Reliability	Interrater reliability measures the consistency by which issues are assigned to categories and dimensions. A test of five faculty members at the Norwegian School of Management resulted in a low interrater reliability for the latest US SIM issues.

Table 3: US SIM issues classified by categories and dimensions

CATEGORIES	SIM KEY ISSUES	M/T		P/C		I/E	
		M	T	P	C	I	E
Business relationship	Business Process Redesign	2			2		2
	Data Resources	7			7		7
	IS Organization Alignment	9			9		9
	IS Strategic Planning	10		10			10
	IS Role & Contribution	13		13			13
	Organizational Learning	14			14		14
	Competitive Advantage	17		17			17
Technology infrastructure	Responsive IT infrastructure		1		1	1	
	Distributed Systems		3		3		3
	Information Architecture		4	4		4	
	Communication Networks		5		5		5
	Multi Vendor Open Systems		18		18	18	
	Electronic Data Interchange		19		19		19
Internal effectiveness	Software Development				6	6	
	IS Human Resources	8			8	8	
	IS Effectiveness Measurement	11			11	11	
	Legacy Applications		15		15	15	
	Outsourcing	20			20		20
Technology application	Collaborative Systems		11		11		11
	End-User Computing	16			16		16

Note: The numbers in the columns are the ranks of the key issues from the SIM study. For example, the issue "Responsive IT Infrastructure" was ranked first, belonging in this table to "Technology infrastructure" with the dimensions technology, "T," control, "C," and internal, "I."

Q METHODOLOGY

Morgado et al. (1999) suggest extending the analysis of key issues by demonstrating two techniques that might provide greater insight into the concerns of IS managers than the traditional rating method used by most recent studies. They used Q-sort (Brown, 1993, 1996) and interpretive structured modeling (ISM; Warfield, 1991) in a survey of Brazilian banks (Morgado et al., 1999, p. 4):

Q-sort (Stephenson, 1953) and interpretive structural modeling (ISM) (Warfield, 1976) allow researchers and participating IT managers to gain a deeper understanding of the relationships among key issues. A factor analysis of Q-sort data can potentially identify groups of IT managers with similar problems. Studies using a rating scale tend not to categorize managers and thus imply that key issues are homogeneous across IT managers. Clearly, this may not always be the case.

Q methodology is a qualitative and quantitative way of gathering and processing data (in this case, key issues) that requires participants to perform a ranking task (Brown, 1996). By requiring the participants to sort statements into a forced quasi-normal distribution, many of the problems associated with questionnaires (e.g., central tendency, leniency) can be avoided (Kendall & Kendall, 1993).

The issue of ranking versus rating has to be addressed. While previous studies mainly did rating, Q methodology applies ranking. Niederman et al. (1991) asked participants to rate, rather than rank, since rating may seem less taxing mentally because issues can be evaluated one at a time rather than requiring simultaneous consideration of all issues. The main shortcomings of rating are the lack of scale use and the indifference among issues. While the scale in most rating studies ranges from 1 to 10, the range of results is less than half of the scale. For example, while the top issue in Brancheau et al. (1996) got a rating of 9.10 on average, the bottom issue got 5.40. These close ratings cause indifference among issues. Ranking forces all respondents to utilize the complete scale as illustrated in Figure 1, where 24 issues are allocated to 24 available spaces from +4 to -4 in a quasi-normal distribution.

Only two issues can be placed in the most important (+4) and most unimportant (-4) positions, while four issues can be placed in the middle position. One of the main

Table 4: Delphi survey problems

Problem	Problem Description
Consensus	Reported consensus in Delphi studies is somewhat illusory. Rather, what is reported traditionally is not consensus, but possibly an aggregation of concerns that are quite different for disparate groups of respondents (Hart et al., 1985).
Interaction	Independent consideration of key issues disregards interaction between issues. For example, an unimportant issue might be an important driver for a key issue.
Theory	Application of theory is lacking in key issues modifications.
Difference	Differences in rating scores are low; i.e., the full potential of scales is not utilized. For example, while a scale from 1 to 10 is provided, the highest rated issue achieves 9.10 and the lowest rated issue achieves 5.40 in the 20 key issues list in Brancheau et al. (1996).

Figure 1: Q-sort for key issues survey

-4	-3	-2	-1	0	+1	+2	+3	+4
X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X
		X	X	X	X	X		
				X				

assumptions of Q methodology is that taken together, all of the issues used in the Q-sort represent the possible domain of opinion on the topic existing in the organization (Kendall & Kendall, 1993). In our research, this implies that the issues identified initially require theory to represent the possible domain of opinions about key issues. This was accomplished by covering all combinations of categories and dimensions as defined by Niederman et al. (1991).

INITIAL SELECTION

The Norwegian context has to be addressed. This context is of importance both in the key issues selection process and in the key issues revision process, as well as in comparisons of results with studies from other nations. Previous key issues studies have primarily addressed the context after survey completion for comparison of results. One important context element is organization size. Wang (1994) found that size, measured in total IS budget, number of total employees and number of IS staff, has a significant influence on the relative importance of IS management issues. Disregarding the context element of organization size implies that surveys in nations with large organizations like the USA may contain the same initial key issues list as surveys in nations with small organizations like Norway. Watson et al. (1997) suggest that context elements should include national culture, economic structure, political/legal environment and technological status. Disregarding context elements of, for example, economic development implies that surveys in nations with developed economies (Mata & Fuerst, 1997) like Australia, Norway and the United States may contain the same initial key issues list as surveys in nations with developing economies such as Costa Rica, India and Slovenia. Burns et al. (1993) addressed the context and dropped five US SIM issues before their Hong Kong survey was conducted.

Old key issues were derived from the most recent US SIM study (Brancheau et al., 1996) and a recent Norwegian study which adopted the US SIM study results (Olsen et al., 1998). Ideas from Norwegian CIOs were obtained through a focus group meeting (Krueger, 1994). The theoretical framework consisted of four categories and three binary dimensions suggested by Niederman et al. (1991). A total of 32 different issues are possible by combining categories and dimensions. However, business relationships are by definition concerned with external issues, thereby excluding internal issues. Furthermore, internal effectiveness is by definition concerned with internal issues, thereby excluding external issues. Hence, the

Table 5: Structured sample of key issues for a Q-sort

C	D	Key Issues	Sources	#
BR	MPI	*NA: BR only external*	*NA: BR only external*	
BR	MPE	Improving Links between Information Systems Strategy and Business Strategy	Expanded from Olsen et al. (1998) and Brancheau et al. (1996), and suggested by CIO; also found in general MIS literature (e.g., Robson, 1997; Ward & Griffiths, 1996)	1
BR	MCI	*NA: BR only external*	*NA: BR only external*	
BR	MCE	Making Effective Use of Data and Information Systems Resources	Expanded from Olsen et al. (1998) and Brancheau et al. (1996)	2
BR	TPI	*NA: BR only external*	*NA: BR only external*	
BR	TPE	Improving Interorganizational Information Systems Planning	Norwegian context: Most organizations are small and Cooperative	3
BR	TCI	*NA: BR only external*	*NA: BR only external*	
BR	TCE	Improving Control, Security and Recovery Capabilities	Two low-ranked issues combined from Brancheau et al. (1996)	4
TI	MPI	Improving Information Technology Infrastructure Planning	Expanded from Olsen et al. (1998) and Brancheau et al. (1996)	5
TI	MPE	Planning Information Technology Projects for competitive advantage	Adapted from Olsen et al. (1998) and Brancheau et al. (1996)	6
TI	MCI	Managing the Technical Foundation of Information Systems	General MIS literature (e.g., Laudon & Laudon, 1998)	7
TI	MCE	Improving Availability of National and International Networks	Adapted from Dekleva and Zupancic (1996)	8
TI	TPI	Developing and Implementing an Information Architecture	Adopted from Olsen et al. (1998) and Brancheau et al. (1996)	9
TI	TPE	Planning Information Technology for Electronic Commerce	General MIS literature (e.g., Laudon & Laudon, 1998)	10
TI	TCI	Controlling a Responsive Information Technology Infrastructure	Adapted from Olsen et al. (1998) and Brancheau et al. (1996)	11
TI	TCE	Implementing Information Technology for Electronic Commerce	Expanded from Olsen et al. (1998) and Brancheau et al. (1996)	12
IE	MPI	Recruiting and Developing IS Human Resources	Suggested by CIO and adopted from Brancheau et al. (1996) and Olsen et al. (1998)	13
IE	MPE	*NA: IE only internal*	*NA: IE only internal*	
IE	MCI	Reducing IT Projects Completion Time	Suggested by CIO	14
IE	MCE	*NA: IE only internal*	*NA: IE only internal*	
IE	TPI	Improving Computer Operations Planning	Adapted suggestion by CIO	15
IE	TPE	*NA: IE only internal*	*NA: IE only internal*	
IE	TCI	Improving Software Engineering Practices	Suggested by CIOs	16
IE	TCE	*NA: IE only internal*	*NA: IE only internal*	
TA	MPI	Managing Application Architecture Planning	General MIS literature (e.g., Laudon & Laudon, 1998; McNurlien & Sprague, 1998)	17
TA	MPE	Managing Internet Applications	General MIS literature (e.g., Laudon & Laudon, 1998)	18
TA	MCI	Measuring Benefits from Information Technology Applications	Adapted suggestion by CIO, Olsen et al. (1998) and Brancheau et al. (1996)	19
TA	MCE	Managing and Controlling End-User Computing	Adopted from Olsen et al. (1998) and Brancheau et al. (1996)	20
TA	TPI	Ensuring Quality with Information Systems	General MIS listerature (e.g., Laudon & Laudon, 1998)	21
TA	TPE	Scanning Emerging Technologies	General MIS literature (e.g., Laudon & Laudon, 1998; McNurlien & Sprague, 1998; Robson, 1997, p. 357)	22
TA	TCI	Assuring Software Quality	General MIS literature (e.g., Laudon & Laudon, 1998)	23
TA	TCE	Implementing and Managing Knowledge Work Systems	Adopted from Olsen et al. (1998) and Brancheau et al. (1996)	24

theoretical framework requires generation of 24 key issues to cover all dimensions and categories.

The issue of selection of respondents has to be addressed. The typical key issues study uses the IT manager (CIO) as respondent. Morgado et al. (1999) asked the highest ranked IT manager in each bank, Swain et al. (1995) asked the information resource manager, Wang (1994) asked the highest ranked IS manager or a high ranked general manager, Dekleva and Zupancic (1996) asked IS managers, and Brancheau et al. (1996) asked SIM institutional and board members. This research follows the same tradition by asking the IT manager.

We generated 24 different key issues listed in Table 5 by crossing the four categories with the three binary dimensions as discussed above. The first column in Table 5 lists categories (C), which are business relationship (BR), technology infrastructure (TI), and internal effectiveness (IE), and technology application (TA). The second column lists combinations of dimensions (D), which are management (M) or technology (T), planning (P) or control (C), and internal (I) or external (E). Two combinations have been excluded for theoretical reasons. First, business relationship issues can only be external issues. Second, internal efficiency issues can only be internal issues.

Q-SORT SURVEY

The Q-sort material was distributed to 769 IT mangers in Norway in September 1998. The mailing consisted of a cover letter, a deck of 24 cards, an instruction sheet, a list of 24 issues (the same as on the cards), a large Q-sort sheet, and a one-page response fax sheet. We knew that the exercise would be time-consuming for respondents, thereby reducing expected response rate. However, Q methodology is a subjective methodology with no requirement for high response rate (Brown, 1980, 1993). We did not do any follow-up to influence response rate. We concluded data collection after one month, having received 58 responses. In this section, we will present the results from our key issues Q-sort survey in Norway in 1998. First, a key issues ranking is presented. Then, three groups of IT managers are identified. Finally, research results are discussed by assigning the groups to stages of IS growth. Analysis was conducted using PQMethod 2.0, which is available at http://www.rz.unibw-muenchen.de/~p41bsmk/qmethod/.

Respondents returned a sheet similar to Figure 1 where issue numbers replaced the Xs. The average score for each key issue is listed in Table 6. “Improving links between information systems strategy and business strategy” received the highest average score, while “scanning emerging technology” received the lowest score.

Table 6 shows that the top five key issues in information systems management in Norway are: improving links between information systems strategy and business strategy, planning information technology projects for competitive advantage, improving interorganizational information systems planning, developing and implementing an information architecture, and controlling a responsive information technology infrastructure.

Improving links between information systems strategy and business strategy was the top key issue in this survey. The issue was expanded from Olsen et al. (1998) and Brancheau et al. (1996), and it was suggested by CIOs. It was also found in general MIS literature (e.g., Robson, 1997; Ward and Griffiths). Approaches to this issue are suggested by Henderson and Venkatraman (1993, 1996), Luftmann (1996) and Venkatraman and Henderson (1993). According to CSC (1998), the single greatest challenge confronting chief information officers throughout the world is to assure that the priorities of their information technology organizations are in line with

Table 6: Key issues ranking

E/I	M/T	C/P	Rank	Issue	Score
E	M	P	1	Improving links between information systems strategy	3.28
E	M	P	2	Planning information technology projects for competitive advantage	2.00
E	T	P	3	Improving interorganizational information systems planning	1.05
I	T	P	4	Developing and implementing an information architecture	1.02
I	T	C	5	Controlling a responsive information technology infrastructure	1.02
I	M	P	6	Recruiting and developing IS human resources	.09
I	T	C	7	Assuring software quality	0.86
I	T	P	8	Ensuring quality with information systems	0.36
I	M	C	9	Reducing IT projects' completion time	0.34
E	M	C	10	Making effective use of data and information systems resource	0.31
I	M	C	11	Measuring benefits from information technology applications	0.16
E	M	P	12	Managing Internet applications	-0.02
I	M	P	13	Managing application architecture planning	-0.10
E	T	C	14	Improving control, security and recovery capabilities	-0.21
I	T	P	15	Improving computer operations planning	-0.21
E	T	C	16	Implementing and managing knowledge work systems	-0.34
I	M	P	17	Improving information technology infrastructure planning	-0.47
E	T	P	18	Planning information technology for electronic commerce	-0.78
I	T	C	19	Improving software engineering practices	-1.00
E	T	C	20	Implementing information technology for electronic commerce	-1.10
E	M	C	21	Improving availability of national and international network	-1.41
I	M	C	22	Managing the technical foundation of information systems	-1.67
E	M	C	23	Managing and controlling end-user computing	-1.78
E	T	P	24	Scanning emerging technology	-2.21

the business strategies of their corporations, according to a survey of almost 600 I/T executives from around the world by CSC. "Aligning I/S and corporate goals" has been on the top of their annual survey results list for many years (CSC, p. 5):

> More and more, it's becoming apparent that "aligning I/S and corporate goals" is a different kind of mission. It's not project-oriented like "cutting I/S costs" or "changing technology platforms." Nor is it driven by external innovations such as "connecting to customers, suppliers, and/or partners electronically." The reality is that I/S aligned with corporate goals is what companies must strive to be. It's a way of doing business. A mantra that doesn't change when profits are down or new technologies are introduced.

DISCUSSION

The scientific method for selecting criteria of important issues has to be discussed. Researchers have to be careful as not to put ideas in the heads of respondents. In this research, we conducted a scientifically based method for selecting a group of topics and then sent those topics to the respondents. Just because we had used this method does not mean that the list will be inclusive of their opinions, and who is to say that their reaction will not be, "the academics think these issues are important, therefore these should be the things that I am considering". In other words, are we biasing the responses in the first place. This paper presents no safeguards to prevent this, making it an interesting aspect of future research in the area of key issues studies.

Furthermore, the application of our initial key issues selection procedure has limitations. We only conducted a one-way generation of first key issues by using different sources of input. If we would analyze the generated issues, we would question many of the resulting categorizations and dimensions. For example, to represent TI and TPE in this research (see Table 5), we generated the issue “planning information technology for electronic commerce,” where electronic commerce represents the external focus. However, it could be argued that this issue should be assigned to another category, such as TA. Hence, a two-way generation of first key issues is recommended for future research. By two-way generation we mean an iterative process of matching generated issues to categories and dimensions. Also, interrater reliability should have been evaluated in this research before the survey was conducted. As pointed out in Table 6, interrater reliability measures the consistency by which issues are assigned to categories and dimensions. A test of five faculty members at the Norwegian School of Management resulted in a low interrater reliability for the latest US SIM issues (Brancheau et al., 1996). A similar test should have been done for the issues in Table 5.

The generalization concern has to be addressed. Our research results are based on 58 CIOs in Norway. Brown (1980, p. 67) makes the following comment on gneralizations when Q methodology is applied:

> Generalizations in Q, unlike those in surveys, are not best thought of in terms of sample and universe, but in terms of specimen and type –i.e., we are prepared to say what it is that is of concern to specimen persons of the A type, the factor being a generalized abstraction (based on communalities) of a particular outlook or value orientation. Generalizations are expected to be valid for other persons of the same type, i.e., for those persons whose views would lead them to load highly on factor A.

CONCLUSION

Initial key issues selection and key issues survey approach represent two important methodological choices. In this research, initial key issues selection was extended by applying a theoretical framework combined with considerations of the Norwegian context, earlier key issues studies, key issues selection problems and ideas from CIOs. Q-sort was chosen as the most appropriate survey approach because of its ability to create a quasi-normal rank distribution and enable an analysis of groups of respondents.

This study opens up several directions in future research. First, how can we keep a practical relevance and avoid issues which are too broad and abstract caused by the theoretical framework? Second, how do results from other key issues studies compare with this study? Third, how can interpretive structural modeling (ISM) be applied to the results of this study?

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Chapter IX

Managing Strategic IT Investment Decisions From IT Investment Intensity To Effectiveness

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Many information technology projects fail, especially those intended as strategic. Yet, there is little research that attempts to explain the link between the IT investment intensity of strategic investment decisions (SIDs) and organizational decision-making, in order to understand this phenomenon. This paper proposes an analytical model employing a number of constructs: effectiveness of decisions, interaction and involvement in the decision-formulating process, accuracy of information and strategic considerations in the evaluation process, rarity of decisions, and the degree of IT intensity of an investment in strategic investment decisions. The model explores the relationships influencing the effectiveness of decisions. Empirical testing is based on a sample of 80 SIDs from Taiwanese enterprises. The results show that interaction, accuracy of information, and strategic considerations are mediators in the linkage of IT investment intensity and the effectiveness of SIDs. The implications of these findings for the management of strategic IT investment decisions are discussed.

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INTRODUCTION

Control issues have been given lower priority than the planning or organizational problems of information management (Earl, 1989). Making effective investment decisions for strategic IT projects has become a critical task. Numerous cases of successful information systems have been cited as a basis for encouraging the strategic use of IT. However, other cases (e.g., the computer-aided dispatch system of the London Ambulance Service) have been failures. For the London Ambulance Service "the single most important factor was the inadequacy of the organization to control such large and technically complex operations" (Hougham, 1996). Such experiences demonstrate the critical importance of managing strategic IT investment decisions (SITIDs) effectively.

Research into SITIDs is not new. Clemons and Weber (1990) provide some principles on which to base an evaluation of a strategic IT venture. Other studies focus on evaluating IT projects (Willcocks, 1992) and report the difficulties involved in evaluation processes (Clemons, 1991). However, evaluation is only one part of the investment decision-making process. It is insufficient to manage SITIDs only through evaluation activities. Weill and Olson (1989) emphasize that "the first step in managing IT investment is to know exactly what that investment is." It is, therefore, necessary to clarify the nature of SITIDs.

SITIDs form part of corporate strategic investment decisions (SIDs). However, research has concentrated on either SITIDs or SIDs, ignoring the continuous nature of decisions (Simon, 1977). Decisions can be distinguished according to several dimensions, including strategic versus operational, structured versus unstructured, and dependent versus independent. SIDs have different degrees of IT intensity that are also an important dimension of the IT/non-IT continuum. Chou, Dyson and Powell (1997) find IT investment intensity to be negatively associated with the effectiveness of SIDs. However, how IT investment intensity and the effectiveness of SIDs are linked has not yet been convincingly demonstrated and further investigation is needed.

Dean and Sharfman (1996) point out that management may use different processes to make different types of decisions. Further, Mohr (1982) argues that the link between decision process and outcome is so intimate that "the process is itself an outcome." Taken together, these two arguments may imply that the link between IT investment intensity and the effectiveness of SIDs is not a direct one and the impact of IT investment intensity may be through the decision process. If different degrees of IT intensity lead to different processes, which, in turn, lead to different outcomes, then it is important to know what factors can act in this kind of role, so that they can be taken into account in the evaluation and management of SITIDs. This paper proposes an integrative framework for exploring the relationship between IT investment intensity and the effectiveness of SIDs. The framework is used to gain additional insight into the linkage. The possible relationships are, therefore, derived from the framework. This paper uses survey data from Taiwanese manufacturers to test the hypothesized relationships.

TOWARDS AN EXPLANATORY THEORY OF EFFECTIVENESS OF SITIDS

In order to study SITIDs, this paper employs the concept of "contextualism" as advocated by Pettigrew, McKee and Ferlie (1988) and adopted by Farbey, Land and Targett (1993), and Ketchen, Thomas and McDaniel (1996). This school integrates process, content and context to study organizational decision-making. Based on Pettigrew's arguments, content refers to the particular decision under study. This dimension explores the basic nature and scope of SIDs. The process refers to the actions, reactions and interactions of the various interested parties as they seek to make a commitment to allocate corporate resources. This dimension incorporates both the formulation and evaluation processes. The context includes the outer context, which refers to the national economic, political and social context for an organization, and the inner context, which is the on-going strategy, structure, culture, management and political process of the organization. This dimension helps to shape the process of decision making.

In the linkage between IT investment intensity and the effectiveness of SIDs, the precise roles of decision process, content and context are not clear. In the social sciences, moderators and mediators have long been identified as two functions of third variables. Baron and Kenny (1986) explain these as follows: "the moderator function of third variables, which partitions a focal independent variable into subgroups that establish its domains of maximal effectiveness in regard to given dependent variables; and the mediator function which represents the generative mechanism through which the focal independent variable is able to influence the dependent variable of interest."

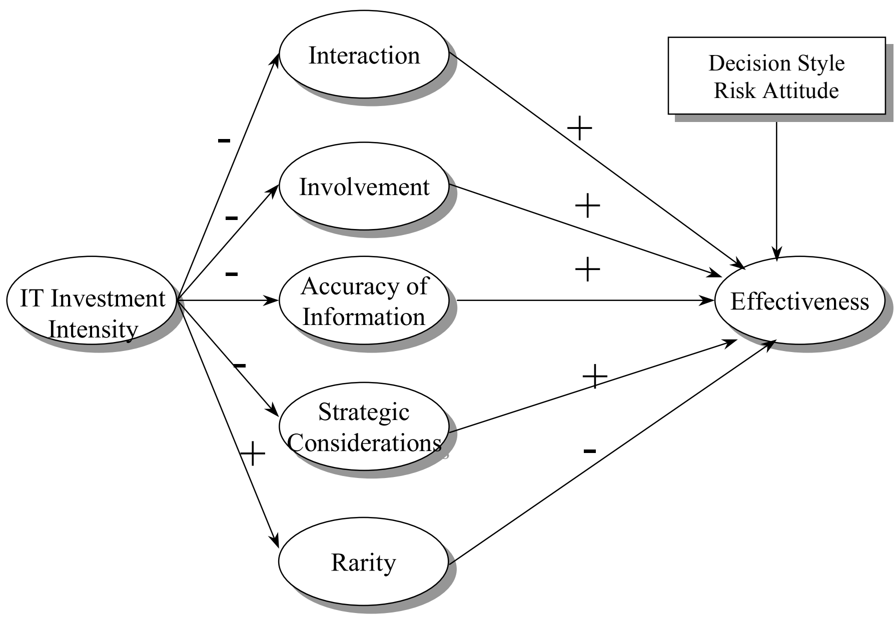
As discussed, the impact of IT investment intensity on the effectiveness of SIDs is through the decision process. Accordingly, the process constructs should have a mediating effect in the linkage. Greater IT intensity will lead to a more technically orientated project that has a different impact upon the effectiveness of SIDs. The decision content, therefore, can also have a mediating effect between the linkage of IT involvement and the effectiveness of SIDs. As part of the context, the organizational investment context has an impact on the outcome of investment. Therefore, the context constructs should act as covariances that impact upon the effectiveness of SIDs. Decision context, decision content and decision process may involve many constructs, and some of them may not be related to IT investment intensity. Two criteria are employed for the selection of constructs and these form the hypothesized relationships for further investigation. First, the construct must be expected to vary according to different degrees of IT investment intensity. For example, importance of decisions is a key characteristic for defining all strategic decisions (Eisenhardt & Zbaracki, 1992). All strategic investment decisions are critical to the organization no matter whether IT is involved or not. Therefore, this paper does not predict any hypothesized relationships concerning the importance of decisions. Second, the construct must impact at the decision level, not the organizational level. For example, a "competitive threat" is a pressure for the whole organization, not just for the outcome of specific decision. This study, therefore, does not hypothesis this relationship. Figure 1 presents a conceptual model of the constructs used and the pattern of relationships among them. The next section develops the rationale and presents a series of hypotheses. The results of an empirical test of the hypotheses are then presented.

The hypothesized negative impact of IT investment intensity on several of the constructs suggests that projects with a high degree of investment intensity present a greater challenge to organizations that, if not understood, can lead to the higher failure rate of such projects.

Effectiveness of Decisions

Research relating to *effectiveness* can be categorized into two groups. The first is concerned with organizational effectiveness and focuses on the relationship between investment decisions and organizational performance. For example, empirical studies investigate the relationship between strategic investment announcements and stock price (e.g., Woolridge & Snow, 1990). They focus on the relationship between announcements and decisions, not the outcomes of the decisions. Although organizations announce their strategic investment plans and the stock market usually reacts positively, the outcomes are unknown. The current work belongs to a second group that focuses on decision effectiveness. Here, effectiveness compares actual performance against planned, whether original or subsequently chosen, target/outputs, outcomes and policy objectives (Willcocks, 1994). It can be measured by items such as project success, correct choice, unexpected negative outcomes, overall learning, and satisfactory process (Butler,

Figure 1: The theoretical model



Davies, Pike & Sharp, 1993). Butler et al. further define effectiveness in terms of objectives-attainment and learning. In the context of this study, "learning" is not considered as it is a feature of all SIDs, no matter the degree of IT intensity. Here, only objective-attainment is taken into account. Thus, effectiveness refers to the objective-attainment of SIDs.

Different Degrees of IT Intensity

This research employs a concept of *IT investment intensity* as a dimension of strategic investments. The concept of IT intensity is similar to, but also somewhat different from, the concept of information intensity. Information intensity is the degree to which information is present in the product/service of a business (Porter & Millar, 1985). The degree to which IT is present in an investment decision reflects the IT level of intensity of that decision. In this paper, IT investment intensity is defined as the ratio of spending on IT to total investment. Harris and Katz (1991) use a similar construct that they define as the ratio of IT expenses to total operating expenses. Harris and Katz measure IT investment intensity at firm level, while here it is used at project (or decision) level. The authors demonstrate the use of this variable by others in analyzing the relationship between firm size, performance and computer use; the extensiveness of computer use; and "system-intensiveness" in commercial banks. Here, it is posited that the higher IT investment intensity, the more important IT is to the whole investment. This is in line with McFarlan, McKenney and Pyburn (1983), who see IT investment intensity as a prime measure of operating dependency on the technology. Accordingly, a strategic IT investment decision is a strategic investment decision that has a high level of IT investment intensity.

Decision Context

Investment context (or climate) is affected by the financial health and the market position of the organization, industry sector pressures, the management and decision-making culture, and business strategy and direction (Butler Cox, 1990). As Cooke and Slack (1984) indicate, "in terms of decision effectiveness, it may be more appropriate to choose a management style on the basis of the particular decision being faced, and only then to overlay this with longer term considerations." The SID, like Pettigrew's (1973) definition of a "non-programmed innovative decision," needs to adopt a change that is new to the organization and to the relevant environment. This characteristic seems more suited to managers who have an innovative attitude to risk. From the perspective of style, the quality of the decisions reached by any process is dependent on the resources that the leader is able to utilize (Vroom & Yetton, 1973). Consensus-driven management seems able to acquire more information than directive management, and this leads to more effective decisions. Management's *attitude to risk* and *decision-making style* are predicted to relate to the effectiveness of SIDs since the other factors will impact at a general organizational level, not upon a specific decision.

Decision Process

Many researches have focused on the importance of the decision process (e.g., Eisenhardt & Zbaracki, 1992; Fahey, 1981; Hitt & Tyler, 1991; Mintzberg, Raisinghani & Theoret, 1976; Sabherwal & King, 1995). The strategic decision process involves several characteristics, including comprehensiveness, the extent of rational activity, participation/involvement, duration and type of conflict (Rajagopalan et al., 1993). From a procedural rationality perspective, comprehensiveness is a measure of rationality and is defined as the extent to which the organization attempts to be exhaustive or inclusive in making and integrating strategic decisions (Fredrickson & Mitchell, 1984). This should include such elements as the extent of formal meetings, the assignment of primary responsibility, information-seeking and analytical activities, the systematic use of external sources, involvement of stakeholders, use of specialized consultants, extensiveness of historical data reviewed, the functional expertise of people involved (Fredickson & Mitchell, 1984; Papadakis, 1995), and the extent of informal interaction (Sheppard, 1990). The political nature of organizational decision-making is also widely discussed (Eisenhardt & Zbaracki, 1992; Pettigrew, 1973). Hickson, Butler, Cray, Mallory and Wilson (1986) define "politicality" as the degree to which influence is exerted on the outcome through a decision-making process. The decision set of interests involving interest groups brings politicality into decision-making. Strategic decision-making is not simply a matter of explicating alternatives and choosing between them on the basis of readily available criteria all participants perceive as appropriate (Fahey, 1981). Amongst these process-related constructs, it is predicted that interaction and involvement are related to IT investment intensity.

Interactions are contacts between two or more members of the group and are of importance in the development of group behavior (Cooke & Slack, 1984). It may be expected that higher degrees of IT intensity will reduce the interaction and that this will lead to a reduced effectiveness of SIDs. Decision-makers' computer knowledge, experience, and educational levels are all closely associated with alienated beliefs and attitudes towards IT (Abdul-Gader & Kozar, 1995). Higher IT investment intensity leads to a more technically oriented project. Without IT knowledge and experience, managers cannot discuss the project in depth. It, therefore, reduces the interaction between members and then impacts upon the quality of decision. For the same reason, the study also predicts that a higher degree of IT intensity will reduce *involvement* of both internal and external stakeholders and this will lead to the reduced effectiveness of SIDs. Less involvement will lead to less collective information and, thus, reduce the effectiveness of decisions.

Hypothesis 1: IT investment intensity will reduce interaction and have an adverse impact on decision effectiveness.

Hypothesis 2: IT investment intensity will reduce involvement and have an adverse impact on decision effectiveness.

The evaluation process can be seen as part of the overall decision process, but it is particularly important for investment decisions. An IT investment decision is more problematic than many investment decisions because the cost and benefits are hard to identify and quantify, and the intangible factors present are likely to be significant (Powell, 1993). Therefore, the uncertainty of information used in evaluating IT investment is greater than in relation to other investments. The higher the uncertainty of information, the lower the *accuracy of information*. This paper expects that lower accuracy of information also contributes to reduced decision effectiveness.

Hypothesis 3: IT investment intensity will reduce the accuracy of information and will have an adverse impact on decision effectiveness.

The evaluation problem of IT is really one of alignment, and organizations that are aware of IT's new role have usually made efforts to incorporate IT into their strategic thinking (Farbey et al., 1993). Thus, *strategic considerations* are critical to the evaluation process. As Barua, Kriebel and Mukhopadhyay (1995) indicate, a firm may have to invest in IT, regardless of its underlying cost structure, in response to a competitor's investment. However, there are differing views of the relationship between IT and corporate strategies (Sheppard,1990). Powell's (1993) idea of "the vicious circle of IT investment" highlights the problem of alignment of IT and business strategy. The vicious circle may lead to suboptimal decisions. Accordingly, this paper expects that management may fail to link the strategic purpose of IT with the organization's strategy, and this will lead to reduced effectiveness of decision-making.

Hypothesis 4: IT investment intensity will reduce the strategic considerations and have an adverse impact on decision effectiveness.

Decision Content

Content refers to the particular decision under investigation and is focused on by much previous research (Butler, Davies, Pike & Sharp, 1991; Eisenhardt, 1989). A strategic decision is characterized by novelty, complexity, and the fact that the organization usually begins with little understanding of the decision situation or the route to its solution and with only a vague idea of what that solution might be and how it will be evaluated when it is developed (Mintzberg et al., 1976). Complexity is a major characteristic of strategic decision-making. Complexity relates to the number and variety of factors in the decision unit's environment that impinge on its decision-making behavior (Pettigrew, 1973). SIDs do not exist in isolation; they evolve from the organizational context and have characteristics of their own. Constructs that contribute to the complexity of decision-making include rarity and importance (Hickson et al., 1986). The problem of uncertainty is, therefore, due to the *rarity* and performance of a decision (Butler et al., 1993). Strategic investment decisions are decisions that have a significant impact on the whole firm and on its long-term performance (Marsh, Barwise, Thomas & Wensley, 1988) and are necessary for the firm's survival. Of the two constructs, rarity and importance, the latter is common to all SIDs irrespective of the degree of IT investment intensity. Rarity is the novelty of the decision to the participants (Butler et al., 1993). Ashford, Dyson and Hodges (1988) state that new technologies often require investments of a different nature because of high uncertainty, more widespread organizational impact, and greater strategic importance. Even compared with other new technologies, the life cycle of IT is extremely short, so that the IT component of projects is constantly changing, leading to increased rarity if not uniqueness. Rarity inhibits effective feedback and learning. This paper, therefore, expects that the higher the IT investment intensity, the higher the rarity of decision, which, in turn, leads to reduced decision effectiveness.

Hypothesis 5: IT investment intensity will heighten the rarity of decisions and have an adverse impact on decision effectiveness.

RESEARCH METHOD

In order to investigate the issues above, empirical work was undertaken in Taiwanese manufacturers. The unit of analysis is a single strategic investment project, rather than a discrete decision event, since it is the complexity and politicality that are at issue rather than the organization itself (Hickson et al., 1986) and so that the complete decision process could be analyzed. In order to obtain a sufficient sample, Taiwan, the home country of one author, was chosen, as this provided the most promising access path. Two professional associations, the Chinese Association for Industrial Technology Advancement and the Chinese Productivity Centre, supported the research and advised on selection of and access to organizations considered to be representative of the population.

The sampling frame involved strategic investment projects completed within the last five years where the objectives of the project included the long-term survival of the organization. The manufacturing sector was chosen to avoid inter-sector influences. Identifying the population was a two-stage process: the first stage identified the focal firms in consultation with experts from the associations, and the second stage selected individual projects. The respondents were all senior or middle managers and were involved in the strategic investment process. The constructs were operationalized in the form of a questionnaire that was piloted on two Taiwanese academics with expertise in questionnaire design and five senior managers. As Langley (1989) points out, it is often easier to provide an operational definition of a construct than a formal one. She discusses the lack of "formal" definitions of some of her constructs and the need to develop operational definitions "broad enough to cover most of what the conceptual writers were talking about." Dean and Sharfman (1996) identify this issue, too. The same problem was encountered here as some of the 'definitions' are broad composites. The appendix itemizes the operational definitions and the supporting sources.

The questionnaires were sent to named individuals in 270 selected organizations, with supporting letters from the two associations, and 94 responses were received, of which 80 were valid for the analysis. Respondents were asked to evaluate propositions based on a strategic investment project developed and implemented in the last five years of which they had experience. A sample of the nonrespondents was telephoned, and the reasons for nonresponse included confidentiality, no suitable investment case, or insufficient knowledge of projects. No systematic reason for nonresponse was detected.

Measures

The variables, their operationalization and the sources of variables are presented in the appendix. Most variables are measured by a 7-point interval scale with semantic differentials for the two extremes. IT investment intensity is measured by the ratio of IT spending to total investment. The measure of decision effectiveness is unavoidably subjective: a multi-objective function is used to determine the objective-attainment effectiveness:

$$Effectivenes = Ý(Ij*Aj)/n$$

Ij = the perceived importance of the jth objective,

Aj = the extent to which the jth objective is achieved,

and

n = the total number of different objectives that respondents seek to attain.

DATA ANALYSIS AND RESULTS

Since the scales used to assess process and content constructs combined measures from a number of different studies, it is necessary to confirm their dimensionality empirically. A principal components factor analysis with varimax rotation is conducted to assess convergence within and divergence between scales. This analysis produces five factors representing accuracy of information, strategic consideration, interaction, involvement, and rarity, each having an eigenvalue above 1.0 and together accounting for 62.6% of variance in the data. Table 1 gives items and factor loadings.

All items are consistently discriminated and are accepted for further analysis.

Table 2 presents the means, standard deviations, correlations and coefficient alphas of proposed constructs. Cronbach's alpha is a commonly used measure of reliability of a set of two or more construct indicators. According to Hair, Anderson, Tatham and Black (1995), a commonly used threshold value for acceptable reliability is 0.70. Cronbach's alpha values for the four constructs which have two or more indicators range from 0.74 to 0.89, suggesting the instruments are reliable.

Table 3 and Table 4 aim to test the proposed mediators. According to Baron and Kenny (1986), testing for mediation requires estimation of three regression equations:

1) Regressing the mediator on the independent variable.
2) Regressing the dependent variable on the independent variable.
3) Regressing the dependent variable on both the independent variable and the mediator.

If these conditions hold in the predicted direction, then the effect of the independent variable on the dependent variable must be less in the third equation than in the second.

Table 3 presents the first step of results of the regression analyses which regress mediators on IT investment intensity. Only Model 1, Model 3, and Model 4 are significant in predicting mediators. Thus, only the three proposed mediators—interaction, accuracy of information and strategic consideration—are used for the further tests.

Table 1: Factor analysis (Varimax rotation) of process and content items

Questionnaire Items	Factor Loadings 1	2	3	4	5
1 Accuracy of Information					
Payback	*.80*				
ARR	*.78*				
Productivity	*.69*				
Profit	*.68*				
Time	*.61*				
Intangible benefit	*.61*				
Cost	*.61*				
Intangible cost	*.60*				
Net present value	*.60*				
Capital	*.59*				
Cash	*.47*				
2 Strategic Considerations					
Performance		*.75*			
Competition		*.74*			
Strategic consist		*.66*			
Grow of market		*.64*			
3 Interaction					
Scope			*.74*	*.42*	
Informal			*.71*		
Quality			*.70*		
Formal			*.65*		
Hierarchy			*.56*		
4 Involvement					
External				*.80*	
Internal				*.78*	
5 Rarity					
Rarity					*-.88*
Eigenvalue	*7.466*	*2.324*	*1.765*	*1.473*	*1.365*
Percentage of Variance	*32.5*	*10.1*	*7.7*	*6.4*	*5.9*

Model 6 in Table 4 represents the second step of the test which regresses effectiveness of SIDs on different degrees of IT investment intensity. The model as a whole is significant in predicting the effectiveness of SIDs. Before proceeding to the third step, the control (contextual) variables are added into the Model 6 and the result is presented in Model 7. The result shows IT investment intensity still significant in predicting the effectiveness of SIDs when context variables are under control. Model 8, Model 9 and Model 10 are used to test the mediating effect of proposed constructs. Interaction, accuracy of information and strategic consider-

Table 2: Intercorrelations among constructs

	Mean	S.D.v.	Alpha	1	2	3	4	5	6	7	8	9
1. Investment intensity	38.56	38.02		1.00								
2. Effectiveness	24.93	9.05		-.22*	1.00							
3. Decision style	4.4	1.5		.22*	.15	1.00						
4. Risk attitude	4.6	1.5		.02	.33**	.35**	1.00					
5. Interaction	4.9	1.1	.76	-.22*	.36**	.14	.16	1.00				
6. Involvement	3.9	1.5	.74	-.19	.27*	.04	-.0003	.31**	1.00			
7. Strategic considerations	5.4	1.0	.77	-.27*	.55**	.19	.38**	.37**	.16	1.00		
8. Accuracy of information	4.6	1.9	.89	-.27*	.69**	.29**	.32**	.37**	.28**	.58**	1.00	
9. Rarity	3.7	1.65		.07	-.27*	.15	-.07	-.12	-.16	.17	-.19	1.00

Table 3: Results of regression analyses (Step 1 and Step 2)

	Interaction **(Model 1)**	*Involvement* **(Model 2)**	*Accuracy of Information* **(Model 3)**	*Strategic Considerations* **(Model 4)**	*Rarity* **(Model 5)**
Different Degree of IT Intensity					
Beta (Significance of T)	-.22 (.0481)	-.19 (.0923)	-.27 (.0140)	-.27 (.0132)	-.07 (.5173)
R^2 (Adjusted R^2)	.049 (.036)	.036 (.023)	.074 (.063)	.074 (.062)	.005 (-.007)
F (Significance of F)	4.0 (.0481)	2.9 (.0923)	6.6 (.0140)	6.4 (.0132)	.43 (.5137)
Df	1, 78	1, 78	1, 78	1, 78	1, 78

Table 4: Results of regression analyses predicting effectiveness of SITIDs (Step 3)

	IT-Investment Intensity **(Model 6)**	*IT-Investment Intensity + Context* **(Model 7)**	*IT-Investment Intensity + Context + Interaction* **(Model 8)**	*IT-Investment Intensity + Context + Strategic Considerations* **(Model 9)**	*IT-Investment Intensity + Context + Accuracy of Information* **(Model 10)**
Different Degrees of Intensity					
IT investment intensity	-.22 (.0493)	-2.5 (.0212)	-.18 (.0957)	-.10 (.3057)	-.02 (.7851)
Contextual Variables					
Decision style		.10 (.3474)	.06 (.5817)	.03 (.7156)	-.08 (.3819)
Risk attitude		.30 (.0084)	.27 (.0142)	.14 (.1817)	.15 (.0930)
Mediating Factors					
Interaction			.27 (.0128)		
Strategic considerations				.46 (.0001)	
Accuracy of information					.65 (.0000)
R^2 (Adjusted R^2)	.048 (.036)	.174 (.144)	.240 (.199)	.337 (.302)	.499 (.472)
F ($^{\text{Signif F}}$)	3.9 (.0493)	5.3 (.0021)	5.9 (.0003)	9.5 (.0000)	18.7 (.0000)
Df	1, 78	3, 76	4, 75	4, 75	4, 75

ation are added into Model 7 separately. These three factors all have a negative correlation with IT investment intensity but a positive correlation with the effectiveness of SIDs. Hence, the impact of IT investment intensity is transmitted to interaction, accuracy of information, and strategic considerations and, through that, has an adverse impact on decision effectiveness. Hypothesis 1, Hypothesis 3 and Hypothesis 4 are confirmed, but Hypothesis 2 and Hypothesis 5 are not supported.

Results and Discussion

In this section the results and their implications are discussed. From a statistical perspective, three proposed constructs–interaction, strategic considerations, and accuracy of information–act as mediating factors in the linkage of IT investment intensity and the effectiveness of SIDs because they all reduce the effect of IT investment intensity. All these constructs are process-related. This result strongly supports the results of two previous investigations that show that decision-making processes are, indeed, related to decision success (Dean & Sharfman, 1996) and that process differences are also related to different topics of decisions (Hickson et al., 1986; Sabherwal & King, 1995). This paper finds content-related constructs do not act as mediators in the linkage. Although the rarity of decision is negatively associated with effectiveness of SIDs, it is not related to IT intensity.

Interaction in the formulating process has a mediating effect on the linkage. Interaction is an important factor in the development of group behavior (Cooke & Slack 1984) and it pressures members into line and towards a group decision. IT investment intensity does lead to a lower interaction of the decision group, and this thereby leads to the reduced effectiveness of SIDs.

Strategic considerations act as a mediating variable. From the results, the higher the IT intensity, the lower the strategic considerations, and this leads to the reduced effectiveness of SIDs. This finding demonstrates that the evaluation problem of IT is really one of alignment, and organizations that are aware of IT's new role have usually made efforts to incorporate IT in their strategic thinking (Farbey et al., 1993).

Accuracy of information acts as a mediating variable. The results show the higher the IT investment intensity, the lower the accuracy of information, and this leads to the reduced effectiveness of SIDs. This finding supports Freeman and Hobbs (1991), who find a high incidence of managers ignoring reject signals given by capital budgeting techniques and identify senior management's preference for qualitative information and IT investment as an "act of faith" (Powell, 1995). This suggests that a high uncertainty of information leads to a limited use of capital budgeting techniques.

A further inspection of these models shows that in Model 8, IT investment intensity is still significant at the 0.1 level when interaction is tested as mediator. This indirect transmission of influence from IT investment intensity to effectiveness of SIDs via interaction shows that the effect of IT investment intensity on effectiveness is only partially mediated by interaction. The effect of IT investment intensity on effectiveness of SIDs is completely mediated by strategic consideration and accuracy of information–two evaluation-related constructs. This result implies that, in seeking a better outcome of SITIDs, research that focuses on evaluation factors may not be sufficient to capture the complexity of SITIDs but is, indeed, a necessary and critical aspect upon which to focus.

Ballantine, Galliers and Stray (1994) indicate that firms attempt to evaluate their IT investments by using simpler financial criteria rather than the more sophisticated techniques. However, Clemons (1991) analyses a case described in terms of strategic necessity, which was presented without detailed financial analysis, decision trees, payback, or sensitivity analysis. This induces a "chicken and egg" problem: does strategic necessity lead to the unimportance of information from evaluation? Or, is strategic necessity an excuse because of the lack of information for evaluation?

This paper sheds some light on this. The two evaluation-related constructs are highly correlated. That is, from an IT investment perspective, the alignment of IT and business strategy is problematic if there is a lack of accurate information for evaluation. However, evaluation of IT investments is problematic if there is a lack of the alignment of IT and business strategy. To improve the effectiveness of IT investment, management needs to increase the alignment of IT and business strategy and accuracy of information for the evaluation techniques simultaneously.

CONCLUSIONS AND FURTHER RESEARCH

The era of information management has changed from data processing to information technology. At the same time, the financial attitude to IT has changed from cost to investment (Earl, 1989). Previous studies of SITIDs have ignored the continuous nature of decisions and the relationships between SITIDS and the other non-IT SIDs. This therefore blurs the nature of SITIDs. By employing concepts from the contextualism school, this paper proposed a theoretical model that explores mediators in the linkage between different degrees of IT investment intensity and the effectiveness of SIDs. The research examined survey data based on a sample of 80 SIDs. The findings show that interaction, the accuracy of information and strategic considerations are the most important factors that mediated the impact of IT investment intensity. Willcocks (1992) emphasizes that management now faces a Catch-22 situation with IT investment. They know how important IT is, but they do not know how to evaluate IT projects. From a theoretical standpoint, the implication of the findings is that managers need to pay special attention to the problematic nature of IT investment intensity in SIDs. They should especially focus on facilitating interaction of the players, ensuring the integration of IT strategy with corporate strategy and improving the accuracy of information in order to pursue better decision outcomes.

Further study should focus on (1) the integration of strategic IS/IT planning with evaluation techniques and (2) the use of external experts to increase the accuracy of information. From an evaluation perspective, the criteria and methods used are still not clear. Does this integration require a reappraisal of evaluation? What is the nature of this reappraisal? By mapping these findings to the characteristics of evaluation approaches, further research should offer a basis for developing a new/improved evaluation approach that is better suited to the evaluation of SITIDs.

APPENDIX

Operationalization and Sources

Formulation Process			
Constructs	*Variables*	*Operational Definition*	*Sources*
Involvement	External involvement	Number of external organizations involved (1= few, 7= many)	Fredrickson (1984) Papadakis (1995) Astley et al. (1982)
	Internal involvement	Number of internal departments involved (1= few, 7= many)	Papadakis (1995) Astey et al. (1982)
Interaction	Scope for involvement	Scope for involvement in formal meetings (1= little, 7= considerable)	Frredrickson (1984) Papadakis (1995)
	Quality of interaction	Quality of communication in formal meetings (1= poor, 7= very high)	Miller (1995)
	Informal interaction	Discussions held outside the formal meetings (1= few, 7= many)	Cray et al. (1988) Skivington & Daft (1991) Hickson et al. (1986)
	Formal interaction	Formal meetings required (1=few, 7=very many)	Cray et al. (1988) Skivington & Daft (1991) Hickson et al. (1986)
	Authority	Level of hierarchy involved (1= very low, 7=, very high)	Cray et al. (1988) Papadakis (1995) Hickson et al. (1986)
Strategic Considerations	Consistency	Consistency with business strategy (1= unimportant, 7= very important)	Sabherwal & King (1995)
	Market growth rate	Growth rate of market relative to project(1= unimportant, 7= very important)	Sabherwal & King (1995)
	Competitive position	Competitive position of firm (1= unimportant, 7= very important)	Papadakis (1995)
	Performance	Performance of firm (1= unimportant, 7= very important)	Priem et al. (1995)
Accuracy of Information	Certainty/importance of information	(1) Cost of investment (2) Cash flow at end of each subsequent period (3) Project duration (4) Cost of capital (5) NPV of cash flow (6) Payback period (7) ARR (8) Profit (9) Productivity (10) Intangible costs (11) Intangible benefits For accuracy (1= highly uncertain, 7= certain) For importance (1= unimportant , 7= important) For source (internal and/ or external)	Dean & Sharfman (1996) Mintzberg et al. (1989), Langley (1989)
Rarity	Rarity	Frequency with which similar projects recur (1= very often, 7= seldom,)	Hickson et al. (1986)

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Chapter X

Extending the Technology Acceptance Model Beyond Its Country of Origin: A Cultural Test in Western Europe

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In recent years, the technology acceptance model (TAM) has been widely used by IS/IT researchers in order to acquire a better understanding of the adoption and use of information systems and technologies. TAM is well-established and widely regarded among researchers and academicians as a relatively robust theoretical model for explaining the adoption and use of IT. From a practitioner's perspective, TAM is useful for predicting whether users will adopt new information technologies.

While TAM has been widely applied in the U.S., as the country of origin, there have been no attempts to extend this model to Western Europe. Given the rapid ongoing globalization of business (multinational companies) and networked systems worldwide (resembling a global village), there is a pressing need to understand whether TAM applies in other cultures. However, previous research suggests that the TAM model may not hold equally well across cultures.

This study is an attempt to theoretically and empirically test the applicability of TAM in the Western Europe culture. Thus the study objectives are: 1) to propose whether TAM may well apply to the Western Europe culture using the work of Hofstede on culture's consequences by exploring the impact of cultural differences on the adoption and diffusion of IT-based innovations such as spreadsheets; 2) to empirically test the applicability of TAM in the United Kingdom as a representative country for the Western Europe culture; and 3) to conclude about the applicability of TAM in selected countries of Western Europe based on these theoretical and empirical endeavors.

Therefore, the current study consists of two main parts: I) a theoretical part where IT adoption and diffusion is put in perspective in relation to cultural consequences, and II) an empirical part where an empirical test is carried out in a representative country of the Western Europe region. The study starts with a brief background on spreadsheets and the role they played in the diffusion of computer technology into organizations and sufficient literature about TAM (including its initiation, objective, popularity, and structure) before getting into the main body of the study.

BACKGROUND

The emergence of personal computers and networks as powerful information technologies has been perhaps the single and the biggest factor to impact organizations during the past two decades. Undoubtedly, the entry of personal computers into business began as a specific result of the advent of spreadsheet software. Based on the history of personal computers, spreadsheets may be argued to be the most important application area for personal computers.

Spreadsheets have long been one of the most important computer tools for managers. The power and range of application of spreadsheets have grown dramatically in recent years. Spreadsheet models are being increasingly used in decision-making within organizations (Cragg & King, 1993), supporting a wide range of management functions, including planning, cost and budget modeling, schedule simulation, analysis and presentation, and more advanced management tasks such as forecasting, optimization and uncertainty analysis, and trade-off studies.

During that period, IT adoption and use have been major goals of modern organizations. Research into predicting the factors leading to IT acceptance and use has also received a great deal of attention and has led to a wealth of research. The study of diffusion and adoption of new technologies recently gained new attendance after being very popular during the 1980s. Meanwhile, organizations throughout the Western developed countries started to use computer technology, especially personal computers, on a large scale. This new wave of attention was at least partly initiated by the increasing diffusion of networking technologies and the advent of Internet (Rose & Straub, 1998).

User acceptance is often the pivotal factor determining the success or failure of information system projects (Attewell & Rule, 1984; Davis, 1993; Igbaria, 1993; Swanson, 1988). Researchers in this field have, for a long time, been occupied in investigating the critical factors predicting user acceptance of information technology. Several past studies addressed the main theme "why do users accept or reject

IT systems?" In arriving at a conclusive result, a lot of technical and managerial measures ought to be taken to foster IT acceptance in the organization for its competitive advantage. This will also enable system designers, developers and users to improve user acceptance of the system in the workplace through the design choices of the system (Davis, 1993). Moreover, management can better understand user perceptions and their attitudes toward a given IT system. Implementing all of that via corrective technical and managerial measures will eventually lead to system success.

Recently, researchers in IS have begun to rely on the theories of innovation diffusion to study implementation problems (Brancheau & Wetherbe, 1990; Cooper & Zmud, 1990; Moore & Benbasat, 1991; Prescott, 1995). A literature review by Prescott and Conger (1995), for instance, included 70 IT adoption and use articles based on the diffusion of innovation (DOI) paradigm alone. A major focus of these studies has been how potential users' perceptions of an IT innovation influence its adoption (Moore & Benbasat, 1991). Rogers' seminal work *Diffusion of Innovations* (1995) is one of the most often cited reviews of the perceived innovation characteristics literature. Rogers, in a survey of several thousand innovations studies, identified five antecedents–relative advantage, complexity, compatibility, observability, and trialability–affecting the rate of diffusion of a technology.

Tornatzky and Klein (1982), in a meta-analysis of findings of 75 articles concerned with innovation characteristics and their relationship to innovation adoption and implementation, found that three innovation characteristics (compatibility, relative advantage, and complexity) had the most consistently significant relationships to innovation adoption. Nine years later, Moore and Benbasat (1991). in their work "Development of an Instrument to Measure the Perceptions of Adopting an Information Technology Innovation," found that compatibility is confounded with relative advantage and its existence as a separate construct is not clear.

It is widely accepted among researchers and practitioners that the explosion in end-user computing was mainly fuelled by spreadsheet packages (Benson, 1983; Brancheau & Wetherbe, 1990; Lee, 1986; Mason & Willcocks, 1991). Indeed, this explosion has carried forth a clear signal of the proliferation and prevalence of spreadsheets in the workplace of abundant organizations, and thus it is fair to conclude that the spreadsheet is an observable and trailable technology. Moreover, observability and trialability are rarely investigated, especially when the IT system is commonly proliferated like spreadsheets.

THE TECHNOLOGY ACCEPTANCE MODEL

The technology acceptance model (TAM) was first introduced by Davis (1986). TAM was developed under contract with IBM Canada, Ltd. in the mid-1980s, where it was used to evaluate the market potential for a variety of then-emerging PC-based applications in the area of multimedia, image processing, and pen-based computing in order to guide investments in new product development.

Davis' TAM is quite similar to a diffusion of innovations model. TAM is a well-respected model of IT adoption and use. TAM does not incorporate all Rogers' constructs; it only includes two constructs, perceived usefulness and perceived ease of use. However, the similarity between these constructs and Rogers' perceived relative advantage and perceived complexity is quite clear (Davis, Bagozzi & Warshaw, 1989). Usefulness and ease of use are both believed to be important factors in determining acceptance of IT (Davis, 1989, 1993; Davis et al., 1989; Igbaria, 1993; Igbaria, Zinatelli, Cragg & Cavaye, 1997; Keil, Beranek & Konsynske, 1995). Thus, it is fair to conclude that TAM is a parsimonious diffusion model suitable to predict users' adoption and use of IT.

The importance of TAM can be viewed as multifaceted according to the application of TAM. Davis summarizes the managerial important aspects of TAM as follows: (1) from the perspective of the manager as a potential user of new technology; (2) from the perspective of the manager of the design team or organization responsible for developing new end-user information systems; and (3) from the perspective of the manager of the user organization.

The TAM model is specifically tailored for modeling the user acceptance of computer-based information systems in organizational settings. TAM represents a significant contribution toward establishing a valid motivational model of the user that reflects the impact of design choices on user motivation as a key element in the success of user acceptance testing procedures. Consequently, TAM is suggested to be a promising practical tool for early user acceptance testing. As organizations have incurred high costs for investing in information technology, the diagnostic measures provided by TAM should help practitioners identify and evaluate strategies for enhancing user acceptance. Accordingly, if higher levels of user acceptance are achieved, productivity should be enhanced and greater gains and return on investment would be maintained.

Another important feature of TAM is that it has been subjected to rigorous testing. TAM was successfully tested by several previous empirical studies in North America; however, just few studies were carried out to test the applicability of TAM outside this region. Table 1 shows a selection of those studies by country and the IT examined. It is striking that no single study took place in Europe other than the one investigating the diffusion of e-mail in Switzerland as a country among other ones outside Europe. It has been argued that the TAM model may not hold equally well across cultures (Straub, Keil & Brenner, 1997).

Popularity of TAM

TAM is a tool for assessing and predicting user acceptance of emerging IT, which has gained popularity in recent years (Davis, 1986, 1989, 1993; Davis et al., 1989). TAM has received extensive empirical support through validations, replications, and applications (Adams, Nelson & Todd, 1992; Chin & Todd, 1995; Davis & Venkatesh, 1996; Gefen & Straub, 1997; Hendrickson, Massey & Cronan, 1993; Igbaria et al., 1997; Subramanian, 1994; Szajna, 1994; 1996; Taylor & Todd, 1995;

Table 1: A subset of previous TAM testing studies with IT examined and country

Study	Technology Examined	Country
Davis (1986, 1989)	File editor, Graphics, E-mail	USA & Canada
Davis et al. (1989)	Word processing software	USA
Mathieson (1991)	Spreadsheets	USA
Adams et al. (1992)	E-mail, voice-mail, graphics, word processor, spreadsheets	Canada & USA
Davis (1993)	Text editor, E-mail	USA
Hendrickson et al. (1993)	Spreadsheets & DBMS	USA
Igbaria (1993)	Microcomputers	USA
Taylor & Todd (1995)	Computing Resource Center	Canada
Al-Gahtani (1995; 2001)	Spreadsheets, Computers	U.K.; Saudi Arabia
Chau (1996; 2001)	CASE, PC software package	Hong Kong
Szajna (1996)	E-mail	USA
Straub et al. (1997)	E-Mail	USA & Japan & Switzerland
Igbaria et al. (1997)	Microcomputers	New Zealand
Rose & Straub (1998)	Computers	Arab World
Teo, Lim & Lai (1999)	Internet	Singapore
Lederer et al. (2000)	World Wide Web	USA
Lin & Lu (2000)	Web site	Taiwan
Roberts & Henderson (2000)	Computers	Australia
Venkatesh & Morris (2000)	New MIS	USA

Venkatesh, 1999; Venkatesh & Davis, 1996; Venkatesh & Morris, 2000) by researchers and practitioners, suggesting that TAM is robust across time, settings, populations, and technologies.

In just about a decade TAM gained a decent popularity among researchers and practitioners. As of January 2000, the Institute for Scientific Information's Social Science Citation Index® listed 424 journal citations of the two journal articles that introduced TAM (namely, Davis, 1989; Davis et al., 1989) as quoted by Venkatesh and Davis (2000). During this period TAM has become well-established as a robust, powerful, and parsimonious model for predicting user acceptance.

The parsimony of TAM, combined with its predictive power, makes it easy to apply to different situations; nevertheless, as the parsimony is TAM's strength, it is also the model's key limitation (Venkatesh, 2000). TAM is predictive but its generality does not provide sufficient understanding from the standpoint of providing systems designers with the information necessary to create user acceptance for new systems (Mathieson, 1991). However, we argue that the emerged cumulative wealth of theoretical and empirical research which studied the determinants and antecedents of the key variables of TAM should overcome this potential limitation.

TAM has proven to be among the most effective models in the information systems literature for predicting user acceptance and usage behavior. The original instrument for measuring these beliefs was developed and validated by Davis (1986, 1989, 1993), and Davis et al. (1989); it was replicated by Adams et al. (1992), Mathieson (1991), Hendrickson et al. (1993), and Segars and Grover (1993). The instrument has also been used extensively by researchers investigating a range of issues in the area of user acceptance (e.g., Al-Gahtani, 1995; Dishaw & Strong, 1999; Gefen & Straub, 1997; Igbaria et al., 1997; Moore & Benbasat, 1991; Olfman & Bostrom, 1991; Taylor & Todd, 1995; Trevino & Webster, 1992; Straub et al., 1997; Szajna, 1994; Venkatesh & Davis, 1994, 2000; Venkatesh & Morris, 2000).

Structure of TAM

TAM is a derivative and an adaptation of the theory of reasoned action (TRA; Fishbein & Ajzen, 1975; Ajzen & Fishbein, 1980) designed to understand the causal chain linking technology external variables to its user acceptance and actual use in a workplace. External variables–such as objective system design characteristics, training, computer self-efficacy, user involvement in design, and the nature of the implementation process–are theorized to influence attitudes toward system use and ultimately usage indirectly via their influence on perceived usefulness (PUSEF) and perceived ease of use(PEOU).

TAM posits that two specific beliefs–PUSEF and PEOU–determine one's attitude to use a technology, which has been linked to subsequent behavior (Davis, 1989, 1993; Davis et al., 1989). Further, TAM suggests that PUSEF will be influenced by PEOU because, other things being equal, the easier the technology is to use, the more useful it can be. Consistent with TRA, TAM also suggests that the effect of external variables on attitude is mediated by the two key beliefs.

In other words, TAM postulates that one's attitude toward using and usefulness are predictors of actual system usage. This attitude is in turn determined by two specific beliefs: perceived usefulness, the user's perception of the degree to which using a particular system will improve his/her performance; and perceived ease of use, the user's perception of the extent to which using a particular system will be free of effort (Davis, 1989; Davis et al., 1989).

Both PUSEF and PEOU constructs are tied to an individual's assessment of the enhancement and of the effort involved in the process of using the technology (see Davis, 1989, for a detailed discussion of the theoretical and empirical development of the constructs). Other theoretical perspectives studying user acceptance have also employed similar constructs (e.g., Moore & Benbasat, 1991, employ the construct "relative advantage," which is quite similar to "perceived usefulness," and Thompson, Higgins and Howell (1991) use the construct "complexity," which is a negative connotation of "ease of use").

In summary, attitude theory from psychology provides a rationale for the flow of causality from external variables such as system features, user characteristics and the like (Davis et al., 1989) through perceptions to attitude and ultimately to behavior (i.e., user acceptance). Figure 1 depicts the structure of TAM with its key constructs and the causal links among them. As the purpose of this study is to examine the applicability of TAM in Europe, external variables should be noted to be beyond its scope. Following are short summaries of the constructs constituting the TAM model to be examined in the current research.

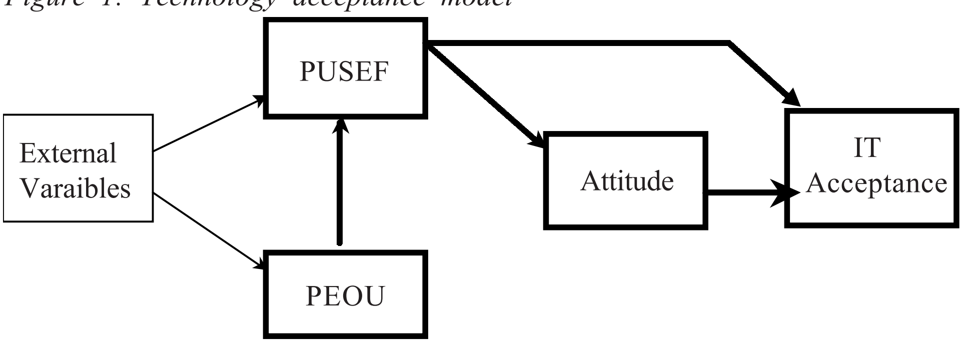
INFORMATION TECHNOLOGY ACCEPTANCE

User acceptance is defined by Swanson (1988) as "potential user's predisposition toward personally using a specific system." Researchers have identified several indicators of IT acceptance. The most generally accepted measures of this construct appear to be user satisfaction and system usage. However, system usage has been the primary indicator of technology acceptance (Adams et al., 1992; Davis et al., 1989; Igbaria et al., 1997; Straub, Limayem & Karahanna-Evaristo, 1995; Szajna, 1996; Thompson et al., 1991). Straub et al. (1995) noted that "system usage has a notable practical value for managers interested in evaluating the impact of IT" (p. 1328). Thus system usage is used here as the primary indicator of IT acceptance and is, as stated earlier, hypothesized to be directly predicted by attitudes and perceived usefulness according to TAM.

ATTITUDE TOWARDS USAGE

Attitudes play a central role in the system-to-value causal chain due to their power and functionality. More specifically, attitudes guide perceptions, information processing and behavior (Fazio, 1988). There are many definitions of the attitude construct. What concerns IS researchers here is a definition that is considered sound by psychologists and that is compatible with the interests of IS researchers. Ajzen (1988) described attitude as a predisposition to respond favorably or unfavorably to

Figure 1: Technology acceptance model



an object, person, event, institution, or another discriminable aspect of the individual's world. Ajzen's definition of attitude emphasizes the notion of evaluation (e.g., pro-con, positive-negative, favorable-unfavorable).

PERCEIVED USEFULNESS

Two specific beliefs, perceived usefulness and perceived ease of use, have been identified as important user acceptance criteria by previous studies (Adams et al., 1992; Davis, 1989; Davis et al., 1989; Goodwin, 1987; Hill, Smith & Mann, 1987; Igbaria et al., 1997). Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his/her job performance" (Davis, 1989, p. 320). The importance of perceived usefulness derives from the TAM model, which proposes that perceived usefulness affects IT usage directly and indirectly through attitudes due to the reinforcement value of outcomes. Adams et al. (1992), Davis (1989), Davis et al. (1989), Straub et al. (1995), and Szajna (1996) reported that user acceptance of an IT system is driven to a large extent by perceived usefulness. Davis (1993) argues that perceived usefulness is the most influential determinant of system usage, underscoring the importance of incorporating the appropriate functional capabilities in new systems. Further, positive association between perceived usefulness and system usage has been reported by several studies (e.g., Al-Gahtani & King, 1999; Davis, 1993; Igbaria, 1993; Thompson et al., 1991).

PERCEIVED EASE OF USE

Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of physical and mental efforts" (Davis, 1989, p. 320). Davis et al. (1989) found that ease of use is an important determinant of system usage operating through perceived usefulness. Goodwin (1987) argues that the effective functionality of a system, i.e., perceived usefulness, depends on its usability, i.e., perceived ease of use. Later, Davis (1993) suggests that perceived ease of use may actually be a prime causal antecedent of perceived usefulness. TAM also postulates that perceived ease of use is an important determinant of attitude toward using a system.

Theoretical Part–Cultural Differences and Technology Acceptance

There has been considerable research directed toward understanding the adoption and diffusion of IT in U.S. organizations (for a review of this literature, see Prescott & Conger, 1995). However, there have been only a handful studies that specifically examine possible cultural effects on the adoption and diffusion of IT (Straub et al., 1997). They add that although research on the impact of corporate culture on IT acceptance provides a useful viewpoint, national culture research undoubtedly has a special character. Yet, based on the research done to date, there is good reason to believe that associations do exist between culture and the acceptance and use of IT.

HOFSTEDE'S FOUR CULTURAL DIMENSIONS AND THEIR POSSIBLE IMPACT ON TECHNOLOGY ACCEPTANCE

Hofstede's seminal research work (1984) on cultural dimensions provides a theoretical foundation for exploring the impact of cultural differences on the adoption and diffusion of IT innovations. He identifies four dimensions that can be used to distinguish among different cultures: power distance, uncertainty avoidance, masculinity, and individualism.

The case of possible impact of Hofstede's cultural dimensions on IT acceptance and use can be built by looking at the interaction between each of these dimensions and some typical characteristics of computer technology. The argument stresses the role of culture towards computers as an important technology for organizations and the possible effect this role has on computer acceptance and use. In the following sections, each cultural dimension is defined and its salient relationship to computer technology acceptance and use is briefly discussed.

Uncertainty Avoidance Related to Technology Acceptance

Hofstede defines uncertainty avoidance as the degree to which members of a society feel uncomfortable with uncertainty and ambiguity. Hofstede (1984) shows that low uncertainty avoidance index (UAI) scores are related to prevalent approaches to scientific–more empirical-pragmatic and rationalistic–activity. They are related to less conservatism, but more relativism and more willingness to take risks in life; they are also related to belief in generalists, common sense, and less showing of emotions. In a word, UAI low scores are related to advanced modernization societies.

Human societies at large as well as organizations use technology to cope with uncertainty. Technology obviously creates short-term predictability as to its outcomes–perhaps at the cost of long-term risks of complete breakdown. Hofstede (1984) elaborates that the use of technology looks extremely rational but even this hides several implicit nonrational value choices (p. 114).

Uncertainty avoidance could affect technology acceptance by influencing choices of computer technology versus traditional means as precursor alternatives to the technology per se. Users might prefer to use some alternatives to spreadsheets, such as pencil and paper or ordinary calculator, to avoid the uncertainty they experience with it. In relatively related research, champions of technological innovations exhibited higher risk-taking and innovativeness (Howell & Higgins, 1990). Based on that, we can conclude that UAI scores are inversely related to computer technology acceptance.

Power Distance Related to Technology Acceptance

Power distance is the degree of inequality among people which the population of a culture considers normal. Hofstede (1984) also shows that low power distance index (PDI) score societies' survival and population growth are more dependent on man's intervention with nature, which leads to more need for technology, which leads to more modern industry and more urbanization.

Straub et al. (1997) argue that in societies in which mangers and workers are separated by a large power distance the leveling effect of computer-based media is not seen or felt as a desirable feature, while workers in cultures in which relatively smaller power distances occur will, accordingly, be able to use such technologies (such as e-mail) in more communications settings. Thus, we can conclude that PDI scores are inversely related to computer technology acceptance.

Masculinity (MAS)

Masculinity (MAS) is described as the degree to which values like assertiveness, performance, success, and competition prevail among people of a culture over gentler values like the quality of life, maintaining warm personal relationships, services, care for the weak, etc. Hofstede (1984) shows that low MAS score societies are more related to quality of life and that conservation of environment is a more important problem than economic growth. They believe in the equality of sexes and sex roles and that women in more qualified jobs are not particularly assertive. Low MAS score societies appeal to job restructuring, permitting group integration, low job stress, and less industrial conflict.

In cultures which are less assertive (low MAS), less socially present media should, therefore, be more acceptable (Straub et al., 1997). In our current study, computer applications like spreadsheets could be a good example of less socially present media. Hence, we can conclude that MAS scores are inversely related to computer technology acceptance.

Individualism (IDV)

Individualism (IDV) is defined as the degree to which people in a culture prefer to act as individuals rather than as members of groups. Technologies developed in Western individualist settings more or less presuppose an individualistic mentality in entrepreneurs, mangers, and workers, which is part of "modernity" (Hofstede, 1984). Hofstede elaborates that introducing such technologies in more collectivist countries represents one of the main forces toward a shift of societal norms in those countries; on the other hand, the collectivist value pattern in more traditional societies sets a limit to the technology transfer possibilities.

Knowledge workers in collectivist cultures (low individualism) cannot pick up cues about the social situation as readily from computer-based media and would therefore be inclined, overall, toward media such as face-to-face across all communications tasks (Straub et al., 1997). Accordingly, we can conclude that IDV scores are proportionally related to computer technology acceptance.

TAM PREDICTIONS FOR CULTURE: THE COMPUTER-BASED TECHNOLOGY SUPPORT INDEX

It has been argued that TAM predictions will not necessarily hold across cultures (Straub et al., 1997). Table 3 shows how the countries selected for the purpose of this study differ in terms of Hofstede's cultural dimensions of (1) uncertainty avoidance (UAI); (2) power distance (PDI); (3) individualism (IDV); and (4) masculinity or assertiveness (MAS) as well as an index composed of these values, namely, the computer-based technology support index (CTSI).

Straub et al. (1997) invented the computer-based media support index (CMSI). They combined Hofstede's indices to create an index for selected cultures. They pointed out that "the purpose of this straightforward, linear index is to mathematically express the simultaneous effect of all four Hofstede's dimensions on the acceptance of E-mail by different cultures. It should only be viewed as a useful approximation" (p. 5). Similar to CMSI, CTSI is developed here with the notion of being general to be applied to various aspects of computing technology.

With respect to the intercorrelations among the four indices, each pair of correlations between IDV and each of the other three indices is always negative. This is a further piece of evidence supporting our earlier conclusion that IDV moves in the opposite direction from the other scales in its effect on perceptions and use of computer media. The IDV index was measured in a range between 0 and 100 (Hofstede, 1984, p. 157). To calculate the CTSI for a particular country, UAI, PDI, and MAS should be added to 100-IDV, in accordance with their argument that IDV moves in the opposite direction from the other scales.

The Computer Industry Almanac (2001) issues a table of the top 15 countries which account for over 70% of the worldwide computers-in-use at year-end 2000. These numbers include all computers, from PCs to supercomputers, used in business, educational institutions and homes. Over 96% of the computers-in-use are PCs. There are about 551 million computers-in-use worldwide at year-end 2000 and over 625 million by year-end 2001.

Only four European countries–namely, Germany, the United Kingdom, France, and Italy–appear among the top 15 countries to be chosen for the purpose of this study. Table 2 shows the four (Western Europe) countries with the U.S. ranked among the top 15 countries with their entries computers-in-use year-end 2000, share of total percentages, and projected year 2001.

To compare Western Europe with the U.S. cultural dimensions and how they relate to IT acceptance, the CTSI index was calculated for these four countries besides the U.S. As can be seen from the CTSI values in Table 3, the U.K. and the U.S. anchor one end of the scale while Germany, Italy, and France occupy the other end. Based on the ordinality revealed through this index and the dimensions of culture, it is possible to predict whether a given culture would support TAM descriptions of computer technology use.

The three selected Western European countries besides the U.S., as the "TAM" country of origin, and the U.K., as the country where empirical test was carried out, are thought to be adequate for this study. These countries with fairly high different Hofstede profiles were chosen to predict the applicability of TAM in the Western European culture. In particular, since France and the U.S. differ markedly on several of Hofstede's dimensions and, thus, on the CTSI index, one might expect to observe significant differences in the applicability of TAM across these cultures.

Straub et al. (1997) found CMSI to be inversely proportional to the degree of supportive of TAM to the specified country. This shows how close the UK is to the USA, which reflects a higher potential supportive degree of TAM. Figure 2 shows that the U.S.'s and the U.K.'s four cultural indices track relatively well together and the CTSI values for both countries are also closer to each other than to any of the other countries. The tendency of the U.K. cultural and CTSI indices gives a strong possibility that TAM would successfully predict the UK experience of computer acceptance and use.

Table 2: Four European countries and the U.S. ranked among the top 15 countries in computers-in-use worldwide

Country (Rank)	Computers-in-Use Year-End 2000 (#M)	% Share of Total (Year 2000)	Computers-in-Use (Projected) Year-End 2001 ($M)
U. S. (1)	168.84	30.64	182.24
Germany (3)	31.59	5.73	35.84
U. K. (4)	25.91	4.7	29.33
France (5)	21.81	3.96	24.97
Italy (8)	17.17	3.11	20.02
Worldwide	551.1	100	625.9

Table 3: Cultural dimensions and CTSI for the U.S. and four European countries

Country	Cultural Values				
	PDI	UAI	MAS	IDV	CTSI
U.K.	35	35	66	89	147
France	68	86	43	71	226
Germany	35	65	66	67	199
Italy	50	75	70	76	219
U.S.	40	46	62	91	157

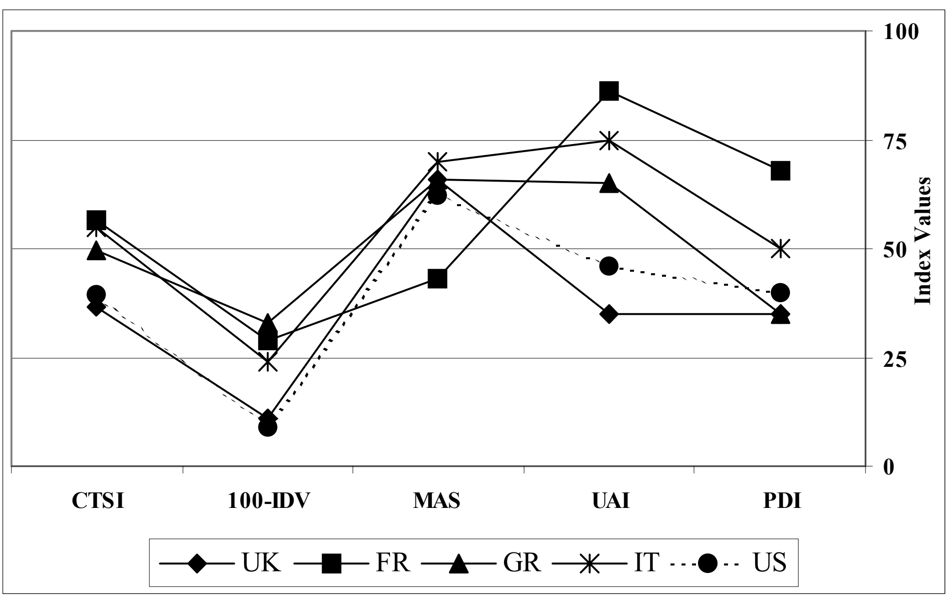
To find how close each of the four countries is to the US as the TAM country of origin, the absolute difference of each country's CTSI score from the U.S. {absolute of [$CTSI_{country} - CTSI_{U.S}$]} is calculated. These absolute values for the four countries U.K., Germany, Italy, and France were {10, 42, 62, 69}, respectively. Combining these values with the CTSI scores, it is clear that the U.K. anchors one end on the continuum of the CTSI scale of cultural values and France and Italy anchor the other end, while Germany occupies a position about the middle.

Let us revert to the main question raised by this study, namely, "Would TAM be applicable to predict whether Western Europe culture would support TAM descriptions of computer technology use?" From Table 3, Figure 2 and the above discussion, it can be seen that TAM is expected to be able to strongly predict the UK acceptance and use of computer technology as it did for the American experience from numerous past studies according to the literature above. On the other hand, we expect that TAM would only be able to moderately predict Germany's acceptance and use of computer technology. Meanwhile, we expect that TAM would not be able to predict well Italy's and France's acceptance and use of computer technology.

RESEARCH HYPOTHESES

As stated earlier, this study appears to be the first attempt to test the applicability of TAM in the UK. It has been argued that culture has effects on IT adoption and diffusion (Harris & Davison, 1999; Hasan & Ditsa, 1999; Straub, 1994). Moreover,

Figure 2: Hofstede's cultural dimensions and computer-based technology support index for selected countries



Straub et al. (1997) argue that TAM predictions may not hold well across cultures. Lacking an a priori rationale for the applicability of TAM in this region, the main question posited by this study was this: "Would TAM be able to predict whether the U.K.'s experience–representing the Western European culture–would support TAM descriptions of computer technology use?"

Specifically, we hypothesize that TAM would very well be able to predict the U.K.'s experience, consistent with its successful predictability of the American experience found in numerous studies, but that it would only moderately predict the German experience. On the other hand, we hypothesize that TAM would not be able to predict well the Italian and the French use of computers.

We further hypothesize (from Table 3) that differences between the U.K. and the U.S. would not be significant as their CTSI and four indices track relatively closer together than either of the other countries. Table 4 presents a summary of the research hypotheses.

EMPIRICAL PART

Research Methodology

A survey questionnaire was developed and administered to explore the applicability of TAM in the United Kingdom as a different culture from that in the U.S.–the country of origin of TAM. In studying the acceptance of IT innovations across different cultures, it is useful to examine technologies that might markedly demonstrate different adoption patterns. From a management perspective, it is also valuable to study technologies that are positioned to achieve major organizational impacts (Straub et al., 1997). A decision support system technology such as spreadsheets meets both of these criteria and was therefore selected for this study.

Table 4: Summary of the research hypotheses

H#	Hypothesis
H1	TAM will fit the U.K. data sample
H1a	Attitude toward using will have a positive direct effect on IT acceptance
H1b	PUSEF will have a positive direct effect on IT acceptance
H1c	PUSEF will have a positive direct effect on attitude toward using
H1d	PEOU will have a positive direct effect on PUSEF
H1e	PEOU will have a positive direct effect on attitude toward using
H2	Overall U.S. TAM will not significantly differ from the overall U.K. TAM
H3	TAM will, theoretically, be more applicable to Germany than to Italy and France

Sample and Procedure

The sample for this study was drawn from final-year students of a university in the Midland of the U.K. Students with a year of full-time placement in industry were approached directly when they returned to school for their final year. The students were registered in business, engineering and science and were required by the university to spend one year in industry in the same area of specialization. The respondents had been employed in a variety of manufacturing, services, merchandising, and financial organizations in a wide range of functional areas throughout the U.K. They were approached in normal class lectures to make sure they had used spreadsheets (the IT system under investigation), to minimize the number of don't knows and no answers and to maximize response rate (Babbie, 1973).

These students are not traditional students, as they have spent one year in the work environment. They consider the year out as a prerequisite for employment, which offers them more motivation to behave and think as company employees. During their year in industry, students in many modern organizations are also given the same training as full-time employees since they are required to apply the same skills to the same type of work. In many ways these students are treated as normal employees during their placement year in the work environment. Since the study concerned their behavior during that year and was administered very soon after their return to the academic environment, these students could be considered as representatives of a junior management group of employees and thus suitable respondents to handle the issues being researched (Al-Gahtani & King, 1999).

By examining the university records of which students went on placements, the researcher found the total number of potential respondents to be 497, which included those who did not use spreadsheets. Based on the aforementioned criteria, 324 responded and completed the survey questionnaire, achieving a response rate of 65%. The majority of respondents were studying some type of business program (59%); 34%, engineering program; and 7%, a science program. Of the respondents, 68% were males, and 32% were females.

Measures

Information technology acceptance. Following researchers in this area (e.g., Davis, 1993; Davis et al., 1989; Igbaria, 1993; Straub et al., 1995), system usage was selected as the primary indicator of information technology acceptance. Based on several studies (Igbaria, 1993; Lee, 1986; Raymond, 1985; Thompson et al., 1991; Trice & Treacy, 1988), five indicators of system usage were included in the survey questionnaire (the fourth indicator being deleted in the final analysis):

1. The actual time spent using the system per day
2. Frequency of use of the system
3. Level of sophistication of spreadsheet applications
4. Number of different spreadsheet applications
5. Variety of spreadsheet software packages and perceived usage level

Perceived usefulness. This construct was measured using a six-item scale adapted from Davis (1989) with appropriate modifications to make the items specifically relevant to spreadsheets. Individuals were asked to indicate the extent of agreement or disagreement with six statements concerning spreadsheets on a 5-point Likert-type scale anchored with (1) strongly disagree and (5) strongly agree.

Perceived ease of use. This construct was measured using a six-item scale adapted from Davis (1989) with appropriate modifications to make them specifically relevant to spreadsheets. Individuals were asked to indicate the extent of agreement or disagreement with six statements concerning spreadsheets on a 5e-point Likert-type scale anchored with (1) strongly disagree and (5) strongly agree.

Attitude toward using the system. Based on the work of Ajzen and Fishbein (1980), a 5-item attitude scale was developed. Attitude toward using the system refers to the person's general feeling of favorable or unfavorable for the use of spreadsheets. The semantic differential method was used to assess the attitude toward using the system. The instrument asked individuals to rate the five items according to how they feel about using spreadsheets by making a check mark in the place that best describes their opinion. Five different pairs forming the evaluation dimensions of the semantic differential were used (*good/bad*, *wise/foolish*, *favorable/unfavorable*, *beneficial/harmful*, *positive/negative*) and participants were asked to respond on a 5-point semantic differential scale.

DATA ANALYSIS

The statistical analysis method chosen for this study was PLS, a powerful approach to analyzing structural models involving multiple constructs with multiple indicators. PLS is a second-generation multivariate technique that facilitates the testing of the psychometric properties of the scales used to measure a variable (i.e., the measurement model), as well as the estimation of the parameters of a structural model, which involve the direction and strength of the relationships among the model variables. Together, the measurement and structural models form a network of measures and constructs (Bagozzi, 1982; Fornell, 1982; Fornell & Bookstein, 1982).

Instrument Validation

The researcher first has to assess the measurement model and then has to test for significant relationships in the structural model. The measurement model consists of the relationships between the constructs and the indicators (i.e., items) used to measure them. This implies the examination of the convergent and discriminant validity of the research instrument, which indicates the strength of the measures used to test the proposed model.

To assess the convergent validity, three tests are recommended. The first test is item reliability, which indicates the amount of variance in a measure due to the construct rather than the error. Hair, Anderson & Tatham (1987) recommended retaining indicators (items) with factor loading of at least 0.50 and considered them very significant. The second test is composite reliability of each measure. Nunnally's (1978) guideline for assessing reliability coefficients was used for evaluating the composite reliability of each measure. The third test is average variance extracted (AVE) by each construct, which indicates the amount of variance in the item explained by the construct relative to the amount due to measurement error (Fornell & Larcker, 1981; Grant, 1989). Fornell and Larcker's criterion that the AVE should be ≥ 0.50 was used to assess the AVE for all constructs.

Discriminant validity refers to the degree to which items differentiate between constructs or measure different concepts. To assess discriminant validity, the correlations between the measures of each pair of constructs are examined. The variance shared between measures of two different constructs (r^2) should be lower than the AVE by the items measuring each construct (Grant, 1989).

The assessment of the measurement model was carried out while examining the convergent and discriminant validity of the research instruments. The revised measurement model was developed based on the results of the assessment.

Results

Testing the Measurement Model

The results of the revised measurement model are presented in Table 5. In general, the results show that the convergent validity of the survey measures was strong. The average extracted variances of the constructs were all 0.50 or above except that for usefulness (0.49). Since all the factor loadings for this construct are considered very significant (l ≥ 0.64) and the reliability of the construct exceeded 0.80, as recommended by Nunnally, this construct was considered satisfactory and thus retained.

Discriminant validity of the research instruments was also tested applying the approach used by Grant (1989). The diagonals representing the AVE as reported in Table 3 were compared with other entries that represent the shared variance which is the squared correlations between constructs. By examining the matrix entries, the 6 non-diagonal entries were found not to exceed the diagonals of the specific construct and thus there being no single violation of the conditions for discriminant validity.

It can be concluded that the convergent validity of the study survey measures was adequate. The average variance extracted and the individual item reliabilities of the constructs appear to be satisfactory, and the composite reliability of all scales exceeded 0.80. Once confidence is gained with respect to the measurement model assessment, the structural model can be evaluated.

Testing the Structural Model

Following the assessment of the measurement model, the structural model was evaluated. To test the estimated path coefficients, t-statistics were produced using jackknifing, which is a nonparametric test of significance (Wildt, Lamber & Durand,

Table 5: Assessment of construct measures (measurement model)

Variables/Measures	Final loadings (λ)	Reliability of a scale[a]	Portion of the variance extracted[b]
Ease of use		0.86	0.51
Ease1	.78		
Ease2	.67		
Ease3	.69		
Ease4	.64		
Ease5	.67		
Ease6	.83		
Usefulness		0.85	0.49
Useful1	.66		
Useful2	.80		
Useful3	.70		
Useful4	.68		
Useful5	.64		
Useful6	.71		
Attitudes		0.83	0.50
Attitude1	.73		
Attitude2	.75		
Attitude3	.69		
Attitude4	.60		
Attitude5	.76		
User acceptance of IT		0.87	0.63
Time of use	.85		
Frequency of use	.84		
Level of applications sophistication	.70		
* Number of applications	—		
Variety and perceived usage level	.76		

[a] Reliability = $(Sl_i)^2 / [(Sl_i)^2 + Svar(e_i)]$

[b] Portion of variance extracted = $Sl_i^2 / [Sl_i^2 + Svar(e_i)]$

* dropped in final analysis

1982). The program used for this analysis was LVPLS 1.6 (Latent Variables Path Analysis using Partial Least Squares), developed by Lohmoller (1981).

The path coefficient of an exogenous variable represents the direct effect of that variable on the endogenous variable. An indirect effect represents those effects interpreted by the intervening variables; it is the product of the path coefficients along an indirect route from cause to effect via tracing arrows in the headed direction only. For more than one indirect path, the total indirect effect is their sum. The total effect of a variable on an endogenous variable is the sum of the direct and the indirect effects (Alwin & Hauser, 1975; Ross, 1975).

The results of the analysis of the structural model are presented in Table 6. To assess the statistical significance of the loadings and the path coefficients (i.e., standardized β's), a jackknife analysis was performed. The use of jackknifing, as opposed to traditional t-tests, allows the testing of the significance of parameter estimates from data which are not assumed to be multivariate normal (Barclay, Higgins & Thompson, 1995). All the five direct paths hypothesized in the structural model were found significant at the 0.001 level.

The predicting variables of the three endogenous constructs and their direct, indirect, total effects on the target endogenous construct, and the variance explained (R^2) are presented in Table 6. The results of these are as follows.

STUDY LIMITATIONS

The sample used for this study was students with one year of experience in heterogeneous organizations across the UK. Although they were treated as normal employees, they could better be considered as representatives of a junior management group of employees. The results of this study are therefore exploratory in nature and should be interpreted with caution. It is suggested that a replication of this study in full organizational settings in the same culture is necessary in order to confirm the implications of these results or otherwise.

Table 6: Results of the structural model predicting perceived usefulness, attitudes, and IT acceptance

Antecedent Variables	**Usefulness**			**Attitudes**			**IT Acceptance**		
	D	**I**	**T**	**D**	**I**	**T**	**D**	**I**	**T**
Ease of Use	0.296		0.296	0.327	0.113	0.440		0.217	0.217
Usefulness				0.382		0.382	0.277	0.117	0.394
Attitudes							0.306		0.306
R^2	0.09			0.33			0.25		

D= Direct Effect I= Indirect Effect T= Total Effect
All effects are at: $p \leq 0.001$

Another limitation is our conclusion of the level of supportive of TAM to Germany, Italy and France cultures. This conclusion is merely based on theoretical inference as explained in the discussion. It is strongly recommended that empirical studies should be conducted in these countries to arrive at a more solid understanding of the level of supportive of TAM to these countries.

DISCUSSION AND CONCLUSIONS

The primary objective of this study was to investigate whether TAM descriptions would be able to predict the U.K. experience of computer technology use. This study sought empirical support for the well-known technology acceptance model, or TAM, in the U.K. Toward that end, the study was successful. The fundamental relationships and linkages among the TAM motivational and cognitive constructs (attitude toward using, perceived usefulness and perceived ease of use) and the outcome construct (IT acceptance) tested in this study were in full agreement with previous research. This finding lends strong support to the applicability of TAM in the U.K. In other words, the TAM general structure (as per Figure 1) appeared to hold for the U.K. culture. Therefore, Hypothesis 1 and all of H1a through H1e are fully supported. This finding presents an important contribution to the application of innovation diffusion research.

The present research is an extension of the work of Davis in three ways: (1) the statistical technique used here (structural equation modeling using PLS) to test the TAM model is more advanced than the multiple regression analysis; (2) the study reported here examines TAM in Europe as a different culture from that in North America; and (3) it also develops and validates the psychometric properties of the ease of use and usefulness scales in a different environment. The two scales were tested for reliability and construct validity. The current research results show that the two scales are both reliable and construct valid for the present sample. This finding is an addition to the two scales psychometric testing which goes along with the several replication and test-retest studies (e.g., Adams et al., 1992; Hendrickson et al., 1993; Subramanian, 1994) that have emerged in the last few years.

The power of explanation achieved by the current TAM study sample is quite acceptable and encouraging. The overall explained variance of the attitudes and IT acceptance (system usage) variables are 33% and 25%, respectively. Although still far less comparable to that achieved by prior TAM studies they can be considered satisfactory for exploratory research. For example, in Davis (1989) the explained variances for two studies were 45% and 49% of system usage. Therefore, Hypothesis 2 is moderately supported.

The Hofstede's four cultural indices and the CTSI index for the UK compared to the US combined with current empirical findings to give a strong support to the applicability of TAM to the UK culture. Projecting on that, it can be concluded (as per Hypothesis 3) that TAM will be theoretically more applicable to Germany than to Italy and France. However, this conclusion is pending for some empirical studies in these countries to be supported or otherwise.

In conclusion, this study makes a contribution to the growing IS/IT literature on technology acceptance and adoption by empirically testing the applicability of TAM in Western Europe. This work should be useful for understanding and improving the chances for successful implementation of IT in this part of the world.

The present study has a number of implications for research and practice. Although this study has limitations, it could be used as an early exploratory stage for extending TAM to Western Europe. This study can be considered an important start for more future empirical research in natural organizational settings in the Western Europe culture.

The current study could be a good example of fruitful research combining substantive theoretical knowledge with empirical investigations. Empirical results show that TAM does provide explanation for IT adoption and use in the UK. By generally inferring from the meanings and values underlying Hofstede's indices, we predicted that TAM would be successful in explaining the UK experience. The empirical part of this study verifies the logical reasoning based solely on substantive theoretical knowledge. Accordingly, we predict that TAM will be theoretically more applicable to Germany than to Italy and France.

The results demonstrated the advantage of the application of the TAM model to information technology. The findings suggest that perceived usefulness, attitudes, and ease of use are the most influential variables in the IT acceptance, respectively. This suggests that system features and functionality of the system must be emphasized to potential users. Thus software developers must address rich system features and powerful system functionality as important design objectives when developing systems. Also, ease of use must not be overlooked as a moderate determinant of IT acceptance. Efforts to improve perceived ease of use, like training, could be used, which will enhance the self-efficacy (Bandura, 1982) of system users.

The TAM model provides diagnostic measures that could help practitioners identify and evaluate strategies for enhancing user acceptance. It lends a promising practical tool to early user acceptance testing (Davis, 1993). It can also be applied to understand the behavior of both experienced and inexperienced users (Taylor & Todd, 1995). Moreover, as TAM constructs mediate between external variables and IT acceptance, there is an opportunity to investigate the effects of external factors (e. g., individual, organizational, and IT characteristics) on perceived usefulness, perceived ease of use, attitudes, and IT acceptance. Hence, if sufficient user acceptance tests are performed early in the implementation process, the risk of user rejection could be reduced, and preventive and predictive measures could be applied to ensure future user acceptance.

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Chapter XI

The Collaborative Use of Information Technology: End-User Participation and System Success

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User participation seems especially important in the development of collaborative work systems where the technology is used by a work group to coordinate their joint activities. Users rather than systems analysts are often the best source of information on how they will use information technology to collaborate. It is almost an axiom of systems development that end users should participate in a broad range of activities/decisions and that they should be permitted to participate in these decisions as much as they want. Despite these widely held beliefs, research has not focused on the differential efficacy of user participation in collaborative versus non-collaborative applications.

Building upon the work of behavioral scientists who study participative decision making, Doll and Torkzadeh (1991) present a congruence construct of participation that measures whether end users participate as much as they want in key systems analysis decisions. Using a sample of 163 collaborative and 239 non-collaborative applications, this research focuses on three research questions: (1) Is user participation more effective in collaborative applications? (2) What specific decision issues enhance user satisfaction and productivity? and (3) Can permitting end users to participate as much as they want on some issues be ineffective or even dysfunctional? The results indicate that user participation is more effective in collaborative applications. Of the four decision issues tested, only participation in information needs analysis predicts end-user satisfaction and task productivity. Encouraging end users to participate as much as they want on a broad range of systems analysis issues such as project initiation, information flow analysis, and format design appears to be, at best, a waste of time and, perhaps, even harmful. These findings should help managers and analysts make better decisions about how to focus participatory efforts and whether end users should participate as much as they want in the design of collaborative systems.

INTRODUCTION

A new era of collaborative organizations characterized by lateral leadership and virtual teams is emerging (Ghoshal & Bartlett, 1997; Pasternack & Viscio, 1998). Firms that compete by developing and deploying intellectual assets are finding that their competitive advantage will depend on developing a superior collaborative capability. Collaboration occurs when two or more people interact to accomplish a common goal. Collaboration means that people who work together support each other by sharing their ideas, knowledge, competencies, and information and/or by coordinating their activities to accomplish a task or goal (Hargrove, 1998). Collaborative work systems are defined as applications where information technology is used to help people coordinate their work with others by sharing information or knowledge. In a longitudinal study, Neilson (1997) describes how collaborative technologies such as Lotus Notes can enhance organizational learning.

Knowledge is a social activity. Complex problems can not be solved by specialists thinking and working in isolation, but in coming together through a process of dialogue, deeply informed by human values and focused on practical problems. Today people from all over the world have the capacity to communicate by e-mail and to participate in electronically distributed meetings. Technology has, in most cases, increased the quantity of interactions people are having. But, has it improved the quality of those interactions? To do this will require a shift in thinking and attitudes towards being more creative and collaborative in systems development (Hargrove, 1998).

Can analysts really design collaborative applications that enhance the quality of human interactions without engaging the application's users in the design effort? In other words, should the design of collaborative applications itself be a collaborative activity? The literature on collaborative systems has focused on: (1) the nature and capabilities of the software, and (2) its application to specific problems requiring collaborative interaction. It has largely ignored the issue of user participation in the design of collaborative applications.

User participation is widely accepted as essential to developing successful information systems (Barki & Hartwick, 1994; Ives & Olson, 1984; McKeen, Guimaraes & Wetherbe, 1994). System analysis decisions have a huge effect on the downstream costs, on timing, and on the likelihood of overall system success. Through interviews, surveys or joint application development sessions, the specification of user requirements is thought to improve the quality of design decisions and, thereby, improve the satisfaction and productivity of end users.

Many analyst and user man-hours and considerable expense can be incurred in making sure that the user requirements are correctly specified. Despite the cost and importance of user participation, we have little knowledge of which decision issues are the most important (McKeen & Guimaraes, 1997). Research on user participation has focused more on the form (Barki & Hartwick, 1994) or degree of user participation (Franz & Robey, 1986) rather than the efficacy of specific decision issues. More emphasis should be placed on identifying the key decision issues and how those issues might differentially relate to satisfaction and productivity.

Few doubt whether users should participate in systems analysis decisions. However, should they participate as much as they want? Studies have shown that most end users want (desire) to participate more than they are actually permitted to participate in the development of applications that they use (Doll & Torkzadeh, 1989). Participatory arrangements, time constraints, and resources often constrain user participation and limit its potential (Doll & Torkzadeh, 1991).

User participation seems especially important in the development of collaborative work systems where the technology is used by a work group to coordinate their joint activities. Collaborative systems are especially difficult to design and require user input. Several interacting users are involved and their collaborative requirements emerge from a changing task context. User experience with the emergent nature of this collaborative activity is essential to effective systems design. In collaborative systems, users rather than systems analysts are often the best source of information on how they will use these applications to coordinate their work.

Managers and systems analysts would like to encourage further end-user participation. However, such efforts can be costly and time-consuming, especially when they are not well-focused on specific issues. We have little information on what decision areas are the most effective avenues for user participation. Despite the growing importance of collaborative systems, no research studies have specifically focused on: (1) which decision issues are the most effective for improving user satisfaction and task productivity, and (2) whether end users should participate in the development of collaborative systems as much as they want.

COLLABORATIVE APPLICATIONS AND USER PARTICIPATION

The interest in and adoption of collaborative applications are being driven by the needs of organizations to address fundamental business problems, specifically those relating to becoming more flexible organizations, shortening time-to-market, and, above all, becoming more responsive to customers (Marshak, 1994). Historically, information technology was used to support individual users and their needs. Computer systems that were used by groups of people, e.g., transaction processing applications, were usually geared toward aggregations of individuals. That is, each user is seen by the system as a discrete unit or a point of input in a sequential process; there is little or no direct interaction, collaboration, or shared work among the users (Johansen, 1988).

In the 1980s, information technology was seen to be a way to support and empower ad hoc teams to meet these needs. Initial applications were aimed at providing a method for these teams to communicate; particular emphasis was placed on teams that could not meet in real time due to organizational or locational differences. Applications such as e-mail, conferencing and bulletin boards provided these teams with the ability to brainstorm, share their findings, and, in some cases, work collaboratively.

For some time now, organizations have turned their focus from supporting teams and groups to looking at their business processes and figuring out how to redesign, support, and manage them to achieve the same overriding goals that has brought attention to teams (Davenport, 1993; Harrington, 1991). Kock (1999) describes how collaborative technologies can facilitate process improvement and enhance organizational learning. Thus, the focus has shifted from the team to the process and, in particular, to the business goal of the process–a satisfied customer and a quality product with short time-to-market.

David Marshak (1994) argues that by the year 2000, collaborative systems will disappear entirely as separate application category. He argues that as applications are redesigned around this process focus and the technologies currently grouped under the umbrella of groupware or collaborative systems become ingrained in the way we work, collaborative systems will simultaneously become transparent and ubiquitous, thus disappearing forever as a separate category of application. If this is true, researchers have to redefine what they mean by a collaborative application.

Paradigms for Defining Collaborative Applications: Design and System-Use

Collaborative applications can be defined in terms of a design or a system-use paradigm. The design paradigm is based on the software designer's intentions. Here a collaborative system is viewed as a separate application category whose primary purpose is to provide technical support for collaborative work, whether it is actually used for that purpose or not. In contrast, the system-use paradigm is behaviorally based. Here a collaborative system is defined as any software application that is actually being used by individuals to help them coordinate their work with others, whether it was specifically designed for that purpose or not.

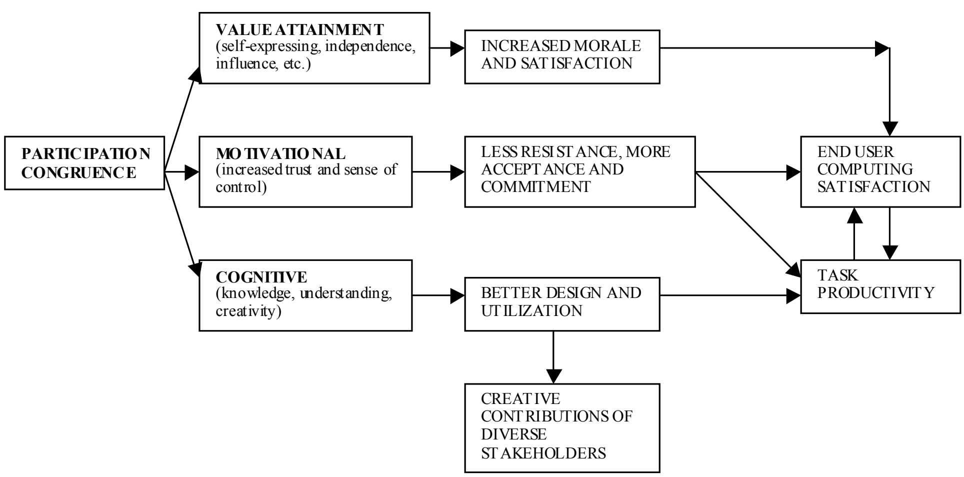
This research adopts the system-use paradigm for several reasons. First, as Schrage (1990) argues in his book entitled *Shared Minds*, the real purpose is not to build collaborative tools but to build collaboration. Second, the real end goals are increased responsiveness to customers, shorter time to market, and increased flexibility. If these end goals are to be achieved, information technology must be used more effectively in the organizational context to help work groups coordinate their joint efforts (Doll & Torkzadeh, 1998). Designer intentions do not, by themselves, contribute to these end goals. Third, if David Marshak is right, many of the software features associated with collaborative systems are already incorporated in much of today's software. Excluding these applications from research on collaborative systems may greatly understate the extent to which information technology has been successfully applied to enhance collaborative work.

This system-use paradigm should have positive effects on the way collaborative systems are designed. It places emphasis on user behavior, rather than designer intentions or technical features. As such, it suggests the need for the analyst to understand not only the technology, but also the dynamic nature of the task context and the changing nature of the relationships between the individuals who use the software. This is information that the analyst can only get from the set of end users who will use the application to help them coordinate their work, i.e., stakeholders. This suggests the need for end-user stakeholders to take an active role in development i.e., making system development a collaborative activity between diverse stakeholders and the analyst.

User Participation in Systems Development

Reviews of the participative decision making (PDM) literature have identified six broad dimensions of PDM, i.e., rationale, structure, form, decision issues, processes, and degree of involvement (Cotton, Vollrath, Froggatt, Lengnick-Hall, & Jennings, 1988; Dachler & Wilpert, 1978; Locke & Schweiger, 1979; Miller &

Figure 1: Psychological mechanisms linking participation congruence to task productivity and end-user computing satisfaction



Monge, 1986; Wagner & Gooding, 1987). Although multiple dimensions have been identified, little systematic theory exists concerning the impact of these diverse dimensions on outcomes (Black & Gregersen, 1997).

Locke and Schweiger (1979) suggest that the key dimension of participation is decision making. The literature on decision issues suggests that both participant satisfaction and productivity or decision quality are, in part, a function of the knowledge or expertise that individuals involved in the decision bring to a particular issue (e.g., Davis, 1963; Derber, 1963; Maier, 1965; Vroom, 1973).

Collaborative applications typically involve a larger and more diverse set of stakeholders than non-collaborative applications used by a single end-user. In this collaborative context, user participation involves determining how this more diverse group of stakeholders will use the application to facilitate their joint efforts. Each stakeholder may have insights based on their work experience that will enable them to make creative contributions to the application's design and utilization.

Locke and Schweiger (1979) provide a theoretical rationale for participation's impact on satisfaction and productivity. They argue that three psychological mechanisms–value attainment, motivational, and cognitive–link participation with enhanced satisfaction and productivity. Doll and Torkzadeh (1989) adapted Locke and Schweiger's theoretical rationale for participation to explain how these psychological mechanisms link user participation in systems development with end-user computing satisfaction.

Figure 1 extends Doll and Torkzadeh's work on psychological mechanisms to: (1) incorporate task productivity as well as end-user computing satisfaction as dependent variables, and (2) illustrate differences between collaborative and non-collaborative applications, specifically the enhanced efficacy of cognitive mechanism's path to task productivity in collaborative applications. Figure 1 is not the model being tested; it is presented solely as a theoretical justification of the hypothesized relationships between participation congruence and its measurable consequences, end-user computing satisfaction and task productivity.

Participation congruence (i.e., when end users participate as much as they want) works through value attainment, motivational, and cognitive mechanisms to bring about benefits. Value attainment refers to whether individuals get what they want (accomplish their objectives or attain their values) through participation. Value attainment leads directly to morale and satisfaction and, through increased satisfaction, it affects end-user computing satisfaction. Enhanced end-user computing satisfaction may also improve task productivity. The value attainment mechanism should be equally effective in both collaborative and non-collaborative applications.

Motivational mechanisms reduce resistance to change and enhance acceptance of and commitment to decisions and changes. These benefits of user participation are attributed to greater trust, greater feelings of control, greater ego involvement or identification with the organization, and higher goals, resulting in enhanced end-user computing satisfaction and improved task productivity. The motivational mechanisms should be equally effective in both collaborative and non-collaborative applications.

Cognitive mechanisms refer to increases in information, knowledge, understanding and creativity that user participation can bring to bear on the task of systems development. In the development of both collaborative and non-collaborative systems, the stakeholders in systems development (i.e., users) make cognitive contributions that improve design or system utilization.

Cognitive mechanisms are expected to be more effective in collaborative applications. Collaborative applications are unique in that diverse users who have varied roles and responsibilities greatly enhance the potential for creative contributions of information, knowledge and understanding. The creative contributions of diverse stakeholders can greatly enhance design, facilitate collaborative use, and improve task productivity.

Since improved task productivity is expected to improve end-user computing satisfaction, we hypothesize:

H1A: User participation is more closely associated with user satisfaction in collaborative than in non-collaborative applications.

However, this hypothesis of a differential association between participation and satisfaction is only supported by the contention that more productive end users are more satisfied with their application.

The association between user participation and task productivity might be expected to be stronger in collaborative applications because of the creative cognitive contributions of diverse stakeholders. Thus, we hypothesize:

H1B: User participation is more closely associated with task productivity in collaborative than in non-collaborative applications.

Decision Issues in Systems Analysis

Reviews of the literature on participative decision making (PDM) generally recommend that managers encourage broad-based participation in a variety of decision-making issues (Locke & Schweiger, 1979). Individuals typically have different interests and differing areas of knowledge/expertise. Encouraging broad-based participation enables individuals to participate on issues important to them (i.e., where they desire to participate) and/or where they have the knowledge/expertise necessary to improve the quality of decision making. Locke and Schweiger contend that PDM may be a waste of time or even harmful to decision quality or productivity if the focal individual has significantly less knowledge/expertise than others. PDM research typically focuses on participation's impact on the quality of decisions and, through better decision making, its resultant impact on employee satisfaction and productivity.

End-user participation in systems analysis activities represents a different context than that normally assumed in the PDM literature. First, the range of possible participatory activities focuses on decisions related to the development of a particular application and is, thus, more constrained. Second, the dependent variables of interest are application specific measures of end-user satisfaction or productivity. Third, within the constrained set of systems analysis activities, end users are not always the best source or only source of knowledge/expertise. In this context, it may be wise to focus participatory efforts on decision issues where end users have superior knowledge/expertise.

Kendall and Kendall (1995) describe the system development life cycle (SDLC) as consisting of seven phases. The first four phases, often referred to as system analysis activities, include: (1) identifying problems, opportunities, and objectives; (2) determining information requirements; (3) analyzing system needs (e.g., information flow analysis); and (4) the logical designing of the information system. Several researchers (Doll & Torkzadeh, 1989, 1990; Edstrom, 1977) have suggested that user participation may be most effective in these system analysis stages where decisions are made on system objectives, user information needs, information flows, and initial input/output screens/formats.

This research identifies four key decision issues for user participation that roughly correspond to Kendall and Kendall's (1995) stages in systems analysis. These key decision issues are referred to as project initiation, information needs analysis, information flow analysis, and format design. Shelly, Cashman, Adamski, and Adamski (1995) describe project initiation as the first stage where the problems and opportunities are identified and objectives for the system are set. In the logical design stage, users participate in prototyping to validate the user interface, i.e., decisions concerning input/output formats or screens. Table 1 describes how the items used by Doll and Torkzadeh can be grouped by Kendall and Kendall's four stages in system analysis.

These key decision issues arise at different times during systems analysis and require different expertise/knowledge. Users may participate in some of these decisions, yet not be available or be otherwise occupied when other decisions are made. Also, user participation in each of these decision issues may not be equally effective. Where managers or systems analysts rather than end users have the knowledge/expertise necessary to improve the quality of decision making, encouraging end users to participate as much as they want may be ineffective or dysfunctional, i.e., resulting in lower quality decisions.

Managers or systems analysts may have a broader view of the organization's business activities/needs and be in a better position to make decisions concerning the initiation of new projects and the determination of project objectives. Determining system needs can require technical skills or knowledge of related systems beyond the scope of the job responsibilities of a particular end-user. A skilled professional may be necessary to trace information flow from source to end user and be sure the "right" information is being used for decision making. End users should be able to judge whether they find a particular format design useful or easy to understand, but they would not normally be as knowledgeable as a systems analyst about the range of possible alternative design formats.

Information needs analysis is a decision issue that is dominated by the end users rather than the analyst. Here the end users have on-the-job experience/expertise and best understand how the application will actually be used to get their work done and to coordinate their activities with others. In a changing job context, these patterns of collaborative work must remain flexible. Collaborative applications must be designed to support this ongoing refinement of how they are used.

Organizational or staffing changes can also affect the relationships between users and how they coordinate their activities. Users of the same application often have different information needs due to differences in their job responsibilities, decision context, or the scope of their personal influence. Even when standard software packages are being installed, differences in the way firms do business may require "work arounds" or modifications to meet the needs of users in a particular firm. Systems analysts typically recognize user expertise in this area by conducting user interviews to determine "what decisions they make" and "what information they need to make those decisions."

User participation is more likely to improve user satisfaction and productivity for those decision issues where the end user has superior expertise or knowledge (Locke & Schweiger, 1979). In both collaborative and non-collaborative applications, end-user expertise is unquestioned in making decisions about information needs. In the other decision issues, line management or information systems professionals may have more expertise or knowledge. Thus, the researchers suggest the following hypotheses:

H2A: Participation in information needs analysis is more effective in improving user satisfaction than participation in other decision issues (i.e., project initiation, information flows analysis, and format design).

H2B: Participation in information needs analysis is more effective in improving task productivity than participation in other decision issues (i.e., project initiation, information flows analysis, and format design).

RESEARCH METHODS

Mindful of Marshak's (1994) argument that, as applications are redesigned around a process focus, technologies currently grouped under the umbrella of collaborative systems will become ingrained in the way we work, the researchers employed the system-use paradigm rather than a design paradigm to define a collaborative application. This methodology also enabled the researchers to assess to what extent information technology is currently being used for collaborative

Table 1: Decision issues in systems analysis

Label for Decision Issues	Kendall and Kendall's Decision Stages	Doll and Torkradeh's Measurement Instrument (Items X1 thru X8)
Project Initiation	Identifying problems, opportunities, and objectives	X1. Initiating the project X2. Determining system objectives
Information Needs Analysis	Determining information requirements	X3. Determining the user's information needs X4. Assessing alternative ways of meeting the user's information needs
Information Flows Analysis	Analyzing system needs (e.g., information flow analysis)	X5. Identifying sources of information X6. Outlining information flows
Format Design	Logical design*, especially the validation of User interface requirements (e.g., prototyping)	X7. Developing input forms/screens X8. Developing output format

Note: *Logical design includes the design of data entry procedures, user interface, files or databases, and controls and backup procedures. Of these, the validation of user interface requirements via prototyping is, perhaps, the best opportunity to involve users.

purposes. The system-use paradigm influenced both the sampling methods and the means for classifying collaborative versus non-collaborative applications.

The Sample

The researchers gathered a sample of 402 end users from 18 organizations, including 8 manufacturing firms, 1 retail firm, 2 government agencies, 2 utilities, 2 hospitals, 2 educational institutions, and one "other." This was half of the firms contacted. In each firm, the MIS directors were asked to identify their major applications and the major end-users for each application. They also consulted with the heads of user departments to identify important end-user applications and their users. A list of respondents was compiled and surveys were distributed via inter-office mail. Responses were obtained from 63% of those surveyed.

Respondents were asked to identify their position within the organization; they responded as follows: 20 top-level managers, 80 middle managers, 75 first-level supervisors, 140 professional employees without supervisory responsibility, and 87 operating personnel. The sample consisted of 139 different applications including profit planning, engineering analysis, process control, budgeting, CAD, CAD-CAM, customer service, service dispatching, manpower planning, financial planning, inventory control, production planning, purchasing, quality analysis, sales analysis, accounts payable and receivable analysis, work order control, general ledger, order entry, payroll, and personnel.

To identify collaborative versus non-collaborative applications, the researchers used a four-item summed scale recently published by Doll and Torkzadeh (1998) to measure horizontal integration, i.e., the extent that information technology is used to coordinate work activities with others in one's work group. The items were:

- My work group and I use this application to coordinate our activities.
- I use this application to exchange information with people in my work group.
- I use this application to communicate with other people in my work group.
- I use this application to coordinate activities with others in my work group.

These items used a 5-point scale (1=not at all, 2=a little, 3=moderately, 4=much, and 5=a great deal). In this sample, the scale has a reliability of .90. The sample of 402 respondents was divided into two groups based upon this four-item scale: 239 non-collaborative applications, i.e., respondents with a score of less than 12; and 163 collaborative applications, i.e., a score of 12 or higher.

The collaborative respondents were substantially more likely to be using a decision support application. The breakdown of the sample by type of application is depicted in Table 2. Sixty-three percent of the collaborative systems were decision support; only 38% of the non-collaborative applications were classified as decision support. Forty-eight percent of the non-collaborative applications were transaction processing while only 25% of the collaborative systems were used to process transactions. Many of the collaborative transaction process applications represented tasks such as service dispatching or customer service that, while transaction processing in nature, required extensive use of the computer to coordinate the activities of the work group.

Table 2: Collaborative and non-collaborative respondents by type of application

	Non-collaborative Applications		Collaborative Applications	
Application Type	Sample Size	Percentage	Sample Size	Percentage
Decision Support	90	38%	103	63%
Database	35	14%	20	12%
Transaction Processing	114	48%	40	25%
Total	239	100%	163	100%

The 139 names of the applications were sorted alphabetically for both collaborative and non-collaborative applications. A comparison between the two lists revealed that, in almost all cases, the same application names appeared on both lists. This indicated that the key issue was not the nature of the application, but rather how the technology was used by the individuals. This observation further supported the system-use paradigm for defining collaborative applications.

Measurement Instruments

In the literature on user participation in systems development, there are two validated instruments: (1) the Barki and Hartwick (1994) instrument, which focuses on identifying the structure and form of user participation, and (2) the Doll and Torkzadeh (1990) instrument, which focuses on decision issues. Doll and Torkzadeh's instrument is used in this research because it identifies 33 decision issues in systems development that are grouped into three factors–system analysis, system implementation, and administration.

Predictive validity analysis (Doll & Torkzadeh, 1990) suggests that only one factor–user participation in systems analysis issues–is effective for improving user satisfaction. System implementation and administration factors had spurious correlations with user satisfaction. Doll and Torkzadeh's research suggests that user participation's effectiveness may be limited to a specific and somewhat narrow set of decision issues in systems analysis.

To measure whether users participate as much as they want in systems analysis, the researchers used a participation congruence instrument developed by Doll and Torkzadeh (1991). To scale participation congruence, respondents are asked how much they desired (wanted) to participate in specific systems analysis decisions and how much they actually did participate using the items X1 to X8 illustrated in Table 1. For each item, the difference between desired and actual participation provides a direct measure of whether the end user participated as much as they wanted. These differences are summed over the eight items to provide a single measure of participation congruence. The scale is reversed; thus, high participation congruence exists when an individual's desire to participate in a specific decision activity equals their actual (i.e., perceived) level of participation.

The congruence instrument assumes a unidimensional construct consisting of a variety of systems analysis activities that have the same or nearly the same impacts on dependent variables such as user satisfaction and task performance. It seems plausible that project initiation, determining information needs, analyzing information flows, and designing input/output formats may require different end-user skills or expertise and that, thus, each of these activities may not be equally effective.

The eight-item congruence instrument is reliable (Torkzadeh & Doll, 1994), distinguishable from its components (i.e., actual and desired participation), and a better predictor of end-user computing satisfaction than perceived participation (Doll & Torkzadeh, 1991).

The eight-item participation congruence scale had a reliability (alpha) of .95 in this sample. The project initiation, information needs, information flows, and format design subscales had reliabilities (alpha) of .92, .89, .88, and .89, respectively. These results suggest that the eight-item scale and each of the subscales have adequate reliability.

Participation is considered effective if it improves user satisfaction with the resultant application or the user's task productivity. To explore the efficacy of the eight-item participation instrument as well as the initiation, information needs analysis, information flow analysis, and format design subscales, the researchers used the 12-item end-user computing satisfaction scale (Doll & Torkzadeh, 1988) and a 3-item task productivity scale. In this sample, the end-user satisfaction instrument has a reliability (alpha) of .93.

The task productivity scale measures a user's perception of a specific application's impact on his/her work. The task productivity items are: "This application increases my productivity," "This application allows me to accomplish more work than would otherwise be possible," and "This application saves me time." A 5-point scale is used (1=not at all, 2=a little, 3=moderate, 4=much, 5=a great deal). In this sample, the task productivity scale has a reliability (alpha) of .93.

Methods for Testing Substantive Hypotheses

H1A and H1B are tested by examining the correlations between the eight-item congruence instrument and the dependent variables–end-user computing satisfaction and task productivity–for both collaborative and non-collaborative respondents. A test of the difference in correlation coefficients between independent samples (Ferguson, 1966) was used to determine whether differences between collaborative and non-collaborative groups were statistically significant.

H2A and H2B are tested in a similar manner using the four subscales for project initiation, information needs analysis, information flow analysis, and format design. However, the four subscales are highly correlated with each other, suggesting the need to test for spurious correlations. For example, the correlations between project initiation and information needs, information flows and format design are .7542, .7303, .7088, respectively. Information needs correlation with information flows and format design are .7966 and .7702, respectively. Information flows also has a .7427 correlation with format design. Thus, correlations between project initiation, information flows, and format design on one hand and satisfaction or productivity on the other might be an artifact of these variables' high correlation with information needs analysis. Thus, even where the correlations were not significantly different, the researchers checked for spurious correlations.

Previous research has shown that the effective range of participation decisions did not include factors such as participation in implementation and project administration. These factors had spurious correlations with user satisfaction, i.e, correlations that were an artifact of their correlation with participation in systems analysis decisions (Doll & Torkzadeh, 1990). Due to this prior evidence of spurious correlation, the researchers felt that they should also examine the subscales measuring project initiation, information needs, information flow, and format design for spurious correlations with satisfaction and task productivity. Partial correlation analysis was used to provide a simple and effective test for spurious correlations.

RESULTS

The collaborative and non-collaborative subgroups are compared in Table 3. The mean scores of overall participation congruence as well as the project initiation, information needs, information flows and format design were not significantly different between collaborative and non-collaborative applications. This indicates that the gap between actual and desired participation is not affected by whether the application is used for collaborative purposes. A reasonable inference is that systems analysts are not making special efforts to encourage users to participate as much as they want in the development of collaborative applications.

The mean scores for end-user computing satisfaction and task productivity are significantly higher for collaborative applications. The biggest change is in task productivity, which changed from 9.7 to 12.1, almost a 25% increase. The researchers wanted to examine whether the higher satisfaction and productivity scores reported in Table 3 for collaborative applications are an artifact of differences in application mix between the collaborative and non-collaborative categories. If users evaluated decision support applications more favorably than the other types, the higher satisfaction or productivity scores for collaborative applications might be due to having a greater percentage of decision support applications in the collaborative category.

Table 4 compares satisfaction and productivity scores by type of application for both collaborative and non-collaborative applications. For each type of application (decision support, database, transaction processing) the end-user satisfaction scores are not significantly ($p < .05$) higher for applications that are used collaboratively. This suggests that the higher satisfaction scores for collaborative applications, as reported in Table 3, are an artifact of differences in application mix. However, differences in application mix do not explain the higher task productivity

Table 3: Analysis of collaborative and non-collaborative subgroups

Dimension	Non-collaborative Applications M (SD)	Collaborative Applications M (SD)	p-value of the difference between means
Overall Participation (X1 thru X8)	29.560 (8.922)	29.683 (9.398)	.4509
Project Initiation (X1 & X2)	7.425 (2.477)	7.608 (2.628)	.2492
Information Needs Analysis (X3 & X4)	7.050 (2.518)	7.316 (2.541)	.1601
Information Flows Analysis (X5 & X6)	7.792 (2.316)	7.533 (2.446)	.1529
Format Design (X7 & X8)	7.136 (2.630)	7.213 (2.626)	.3902
End-user Computing Satisfaction	46.778 (8.566)	49.247 (7.905)	.0022
Task Productivity	9.703 (3.861)	12.104 (2.799)	.0000

Table 4: Analysis of collaborative and non-collaborative by application type

	End-User Satisfaction			Task Productivity		
Application Type	Non-Collab. M (SD)	Collab. M (SD)	p-value of difference between means	Non-Collab. M (SD)	Collab. M (SD)	p-value of difference between means
Decision Support	49.78 (7.83)	49.88 (7.67)	.9292	10.97 (3.82)	12.46 (2.34)	.0016
Database	45.89 (8.74)	47.30 (10.31)	.6084	8.80 (4.16)	11.50 (3.62)	.0154
Transaction Processing	43.57 (9.14)	46.58 (9.64)	.0904	8.98 (3.56)	11.50 (3.24)	.0002

scores for collaborative applications. For each type of application the task productivity scores are significantly ($p < .05$) higher for applications that are used collaboratively than for the same type of application that is not used collaboratively. When applications are used to enhance collaborative work, information technology's potential for improving productivity is enhanced.

Results for Hypotheses H1A and H1B

The results for H1A and H1B are depicted in Table 5. Overall participation congruence has a significant ($p < .01$) correlation with end-user computing satisfaction among non-collaborative and collaborative applications, .3622 and .3679, respectively. This difference is nonsignificant. Thus, H1A, the hypothesis that participation is more effective at improving user satisfaction in collaborative applications, is rejected.

Overall participation congruence has a non-significant correlation with task productivity (r=.0511) among non-collaborative applications. However, it has a significant (p <.01) correlation with task productivity (r=.2533) among collaborative applications. This difference is significant at p < .0212. Thus, H1B, the hypothesis that participation is more effective at improving task productivity in collaborative applications, is not rejected.

This means that, from the perspective of improving user satisfaction, permitting end users to participate as much as they want in systems analysis decisions is equally effective in both collaborative and non-collaborative applications. If the goal is satisfied users, user participation works regardless of the nature of the application.

More interestingly, these results suggest that permitting end users to participate as much as they want in systems analysis decisions is ineffective at improving productivity among non-collaborative applications. A significant participation-productivity relationship is only present among collaborative applications. If the goal is more productive users, user participation appears to work in collaborative applications. The evidence suggests that user participation's power to enhance productivity is more limited among non-collaborative applications.

Socio-technical (Pasmore, 1995; Pasmore & Sherwood; 1978) systems theory provides a possible explanation of these results. This theory says that, to optimize productivity, both the social system and the technical system must be considered in the design of work. Systems that are optimized for technology but do not consider the collaborative social environment of work will be less productive. Collaborative applications are complex social and technical systems. The team or work group can achieve its goals in many ways. User participation enables the analyst to understand how the work group wants to use information technology to get their job done. It enhances both design and utilization by incorporating the creative contributions of diverse stakeholders.

Socio-technical systems theory may also be applicable to non-collaborative applications. However, the low use of these systems to coordinate work with others suggests that these jobs have not, as yet, been redesigned from a process perspective that emphasizes lateral relationships. Here user participation may enhance design, but the design may focus narrowly on the requirements of one user or category of user. Design and utilization do not benefit from the creative contributions of diverse stakeholders. Thus, participation's potential for productivity improvement is limited.

Results for Hypothesis H2A and H2B

Table 5 indicates that project initiation, information needs analysis, information flow analysis, and format design have significant correlations with end-user

Table 5: Correlations between participation congruence dimensions and dependent variables

	End-User Satisfaction				Task Productivity			
Participation Congruence Dimension	Overall (n=402)	Non-Collab. (n=239)	Collab. (n=163)	p-value #	Overall (n=402)	Non-Collab. (n=239)	Collab. (n=163)	p-value #
Overall Participation (X1 to X8)	.3629***	.3622***	.3679***	.4744	.1178**	.0511	.2533***	.0212
Project Initiation (X1, X2)	.2682***	.2544***	.2832***	.3809	.0927	.0067	.2364***	.0111
Information Needs (X3, X4)	.3551***	.3238***	.3943***	.2145	.1625***	.0927	.2764***	.0312
Information Flows (X5, X6)	.2916***	.2691***	.3502***	.1903	.0743	.0332	.2149***	.0354
Format Design (X7, X8)	.3202***	.3329***	.3022***	.3694	.0839	.0256	.2000**	.0418

satisfaction, .2682, .3551, .2916, and .3202, respectively. While information needs has the highest correlation with satisfaction, it is not significantly higher that of the others. Information needs analysis has a significant ($p <.01$) correlation ($r = .1625$) with task productivity while the others have nonsignificant correlations. Again, information needs correlation with task productivity is not significantly higher than project initiations ($r=.0927$), information flows (.0743) or format design (.0839). Thus, without examining partial correlations, H2A and H2B would be rejected.

Because the participation subscales are highly correlated with each other, the researchers conducted a partial correlation analysis using the overall sample of 402 respondents. In Table 6a, the participation congruence dimensions are correlated with user satisfaction and task productivity while controlling for the impact of information needs analysis. With the effect of information needs partialed out, the overall participation scale as well as the participation scales for project initiation, information flows, and format design have nonsignificant correlations with user satisfaction. With the effect of information needs partialed out, the overall participation scale as well as the participation scales for project initiation, information flows, and format design have negative partial correlations with task productivity. Two of these negative partial correlations are statistically significant, -.0963 for overall participation ($p < .05$) and -.1391 for information flows ($p <.01$).

Table 6b reports information needs first-order partial correlations with user satisfaction and task productivity while controlling for each of the other participation subscales. While partialling out the effects of project initiation, information flows, and format design participation, information needs retains significant ($p <.01$) positive partial correlations with both end-user satisfaction and task productivity.

These results provide strong support that participation in information needs analysis is the only active causal agent that predicts end-user satisfaction and task productivity. The researchers conducted this analysis for both the collaborative and the non-collaborative subsamples with almost identical results to those reported in Tables 6a and 6b. In both subsamples, information needs was the only active causal agent predicting satisfaction and task productivity. The significant positive correlations reported in Table 5 between project initiation, information flow analysis, and format design on one hand and user satisfaction or task productivity on the other appear to be spurious.

Table 6: Partial correlations between participation congruence dimensions and dependent variables

Congruence Dimension	End-User Satisfaction	Task Productivity
a. Partial Correlation Analysis Controlling for Information Needs (X3,X4)		
Participation Congruence Dimension		
Overall Participation Congruence (X1 to X8)	.0237	-.0963**
Project Initiation Congruence (X1,X2)	-.0030	-.0520
Information Flows Congruence (X5,X6)	-.0219	-.1391***
Format Design Congruence (X7,X8)	.0546	-.0622
b. Information Needs Partial Correlations With Dependent Variables		
Congruence Dimension Controlled		
Controlling for Project Initiation (X1,X2)	.2429***	.1373***
Controlling for Information Flows (X5,X6)	.2558***	.2183***
Controlling for Format Design (X7,X8)	.2075***	.1515***

Note.* indicates significant level at .10; ** indicates significant level at .05; and *** indicates significant level at .01.

On the basis of this partial correlation analysis, the researchers failed to reject Hypotheses H2A and H2B. The results suggest that, unlike participative decision making where a broad range of decision issues might be effective, the range of effective decision issues in the development of collaborative or non-collaborative applications appears to be limited to a narrow set of decision issues surrounding the assessment of information needs where users have special expertise by virtue of their work experience and training. User participation in project initiation, information flows analysis, and format design appear to be "ancillary" in that they are additional decision activities that might clarify, supplement or embellish our understanding of user information needs. The significant negative partial correlation between information flow analysis and task productivity suggests that permitting end users to participate as much as they want in technical issues where they may not possess unique skills or training may be dysfunctional.

CONCLUSIONS

In this new area of collaborative organizations, information technology offers substantial promise for improving productivity. This sample of major applications at 18 firms reveals that information technology already plays an important role in enhancing productivity by facilitating collaborative work. The key to achieving further productivity gains is to remember that the real goal is not to build collaborative systems, but to use information technology to enhance collaboration. The system-use paradigm is fundamental to this effort.

This study indicates that user participation is more effective in enhancing productivity in the context of collaborative work systems. This suggests that the design of collaborative work systems should itself be a collaborative activity between analysts and users. Moving the analyst-user relationship from participation to collaboration requires a common goal. By focusing both users and analysts on using information technology to enhance collaborative work rather than building collaborative systems, the system-use paradigm provides the common goal necessary to support this transition.

This study suggests that users should be encouraged to participate as much as they want in the development of collaborative applications. While the extent of participation should not be limited, the range of participatory issues should focus on supporting collaborative work by determining the information needs of a broad network of stakeholders who might improve how they work together. Encouraging too much user participation on technical issues such as information flow analysis where users do not have special expertise can be dysfunctional. The results suggest that the range of decision issues that are effective in improving user satisfaction or productivity are narrow and focused around information needs analysis.

This study uses reflective measures of actual and desired user participation obtained after implementation. Scores obtained after implementation may differ from those obtained during the process. Future research efforts might cross-validate these findings using participation measures obtained just after the user engages in project initiation, information needs analysis, information flows analysis, and format design.

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Chapter XII

User Satisfaction With EDI: An Empirical Investigation

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This study was undertaken to identify antecedents of user satisfaction with EDI systems by surveying key end-users of EDI in a variety of firms across the United States. Although there is much empirical evidence about factors underlying EDI adoption and implementation, there is little information from the perspective of the end user. The vast majority of what we know about EDI success (or failure) is based on the EDI manager's or IT perspective. However, there is evidence that suggests if users are not satisfied with a system, they will not use it. Thus, a study of user satisfaction with EDI can provide firms seeking to better leverage their EDI investment with a different and useful perspective on factors that underlie EDI. Two findings indicate that the greater the perceived benefits of EDI, the greater the user satisfaction; and the more compatible EDI is with existing organizational practices and systems, the more satisfied the users are with the system. Although EDI managers may have suspected this was true, empirical support of heretofore largely anecdotal evidence has several implications for successfully managing EDI adoption and integration. These implications hold not only for the adopting firm, but also for firms that may require, or are considering requiring, trading partners to implement EDI. Finally, implications for future EDI research are discussed.

INTRODUCTION

Corporate use of electronic data interchange (EDI), the computer-to-computer exchange of business transactions, has grown rapidly over the last several years (Hart & Saunders, 1997; Turbide, 1994). Although many firms are now engaging in

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Web-based electronic commerce, there is significant investment in EDI, and it remains a widely used form of business-to-business electronic commerce (Ramamurthy, Premkumar, & Crum, 1999; Zwass, 1999). For example, approximately 90% of U.S. Fortune 1000 firms have implemented the traditional value-added-network (VAN)-mediated EDI (Austin, 1998), and the number of firms implementing EDI has grown steadily over the past two decades (Hart & Saunders, 1997). Those that have made substantial investments in EDI are still looking for ways to leverage their investments. In addition, many firms that are pursuing electronic commerce with business partners on the World Wide Web are maintaining existing EDI relationships and using the Web to investigate alternative suppliers or buyers (Carbone, 1999). Others have begun to move away from the traditional VAN-mediated, proprietary EDI framework to use Web-based EDI (Tucker, 1997; Carbone, 1999). However, firms "aren't sure if the Internet will replace EDI. ... Many believe they will use both EDI and the Internet as e-commerce tools" (Carbone, 1999, p. 2). Therefore, EDI is still a viable, widely used electronic commerce technology, and research that can help firms better understand the factors that shape their use of EDI is still relevant.

Much of the research that has been done about EDI has focused on the success of EDI from the organization-level perspective, and EDI representatives or managers are the primary sources of data collection efforts in these studies (Jelassi & Fignon, 1994; Teo, Tan, Wei & Woo, 1995). However, the users are the ones who determine the extent of use and integration in the firm. Because initial EDI adoption has been widely due to external pressures, its adoption is often mandated (Hart & Saunders, 1997; Webster, 1995). However, EDI integration is often limited after initial implementation (Massetti & Zmud, 1996). For example, on average, firms that have implemented EDI use it for less than half their transactions and do business using EDI with less than half their trading partners (Massetti & Zmud). Furthermore, private discussions with firms about their suppliers' use of EDI revealed that some suppliers still manually key in data for purchase orders and invoices, although the same suppliers submit them to their trading partners electronically through EDI VANs, thereby nullifying many of the benefits for which EDI was implemented. Although many factors have been identified to underlie this lack of integration (Saunders & Clark, 1992; Scala & McGrath, 1993; Webster), few have considered the user perspective. However, many EDI managers are not extremely satisfied with the extent to which users have accepted this way of doing business (Arunachalam, 1995). However, without user satisfaction, it is difficult for firms to realize the benefits from an information technology regardless of external pressure to mandate adoption (Barki & Hartwick, 1994; Davis, 1989; Lyytinen, 1987; Rice & Aydin, 1991). "The more receptive an organization is to establishing ... electronic relationships, the more likely that organization is to be successful in adapting and competing within the emerging electronic marketplace" (Massetti & Zmud, p. 337). Thus, user satisfaction with EDI seems critical to a firm's ability to use it to compete effectively in today's marketplace.

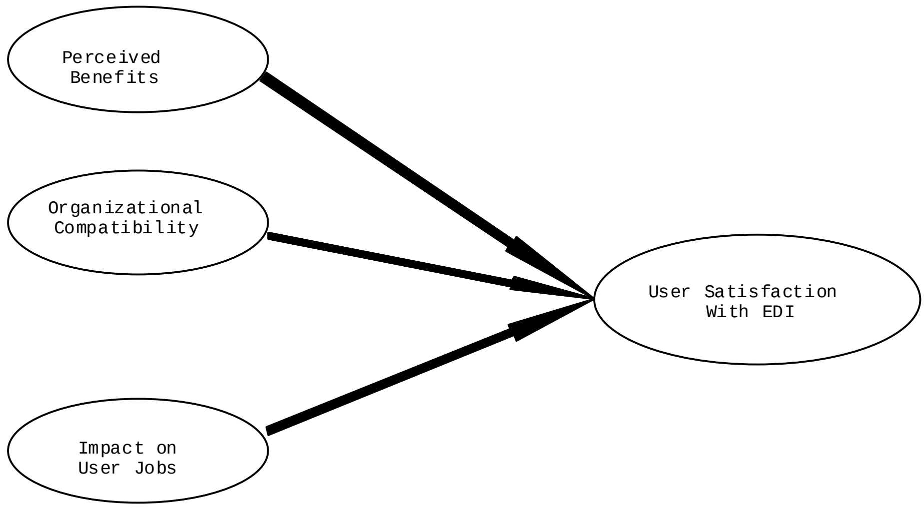
Therefore, this study was undertaken to identify possible antecedents to this satisfaction. Because the unit of analysis is the individual user, the aspects of EDI with which the user most directly interacts are examined. Thus, the study focuses on factors that may influence satisfaction with the ease of use of the interface and with the quality of the output. "The measurement of how satisfied a user is with his or her information system ... has become a pervasive measure of the success or effectiveness of an information system" (Baroudi & Orlikowski, 1988, pp. 44-45). In situations where use is mandatory, satisfaction is thought to be a better surrogate for success than actual use (Ives, et al., 1983). Thus, it seems appropriate to examine user satisfaction with EDI, to use satisfaction as a surrogate for EDI success, and thus to conclude that influences on user satisfaction may also influence EDI success.

USER SATISFACTION

Although user satisfaction has been the subject of much research, there is little convergence in the field about how to properly operationalize or measure the construct (e.g., Delone & McLean, 1992; Ives, Olson & Baroudi, 1983; Klenke, 1992). Measures tend to focus either on general satisfaction or on satisfaction with a specific application (Doll & Torkzadeh, 1988; Omar & Lascu, 1993). One of the most widely used measures of general satisfaction is the Ives et al. (1983) modification of the Bailey and Pearson (1983) scale (Baroudi & Orlikowski, 1988). However, because these scales are designed to measure general satisfaction, they tend to ignore environments in which end users have less direct interaction with the information systems staff. Doll and Torkzadeh argue that in situations where users have limited interaction with the information systems staff, general satisfaction measures are not appropriate. Given that the users probably had little input into the process of determining whether they would use EDI (Morrell, Neal & Fries, 1995), a measure of satisfaction with a specific application seems most appropriate.

Doll and Torkzadeh proposed one of the first instruments containing a set of items to measure end-user satisfaction with a specific application, defining end-user computing satisfaction as "attitudes towards a specific computer application by someone who interacts with the application directly" (1988, p. 261). This instrument captures satisfaction with the content, accuracy, format, and timeliness of the information (output) and with the ease of use of the system (interface), all of which are characteristics of an application rather than the general computing process. One fairly comprehensive assessment of user satisfaction measures found Doll and Torkzadeh's scale to be one of only three such measures to demonstrate adequate measurement properties (Zmud & Boynton, 1991). A second study by its developers also demonstrated the scale to have strong measurement properties including high internal consistency for each dimension as well as the overall scale (Torkzadeh & Doll, 1991). Although there have been some discrepancies in results obtained in attempting to replicate Doll and Torkzadeh's findings (e.g., Chin & Newsted, 1995;

Figure 1: Research model



Etezadi-Amoli & Farhoomand, 1991; Seddon & Yip, 1992), studies that have used the scale indicate that it has value as a measure of end-user satisfaction.

ANTECEDENTS OF USER SATISFACTION

User satisfaction is affected by a variety of factors, including organizational, system, and application variables. Although it can be argued that there are many constructs that may adequately explain user satisfaction with EDI, it is also argued that parsimony in models improves theory building and evaluation (Bacharach, 1989). Applying a manageable chunk of an existing model or models in a new context is deemed more useful at this early stage of exploration, leaving room to expand the boundaries of inquiry in future research (McGrath, 1975). Therefore, upon examining theory about satisfaction with products in general and about user satisfaction with information systems specifically, three constructs that seem to most directly apply to user satisfaction with EDI were chosen for inclusion in the model. These are perceived benefits of EDI, organizational compatibility of EDI, and impact of EDI on the user's job (Banerjee & Gohlar, 1994; Cragg & King, 1993; Iacovou, Benbasat & Dexter, 1995; O'Callaghan, Kaufmann & Konsynski, 1992). Figure 1 illustrates the model examined.

Perceived Benefits

Usefulness of a system has been linked to user satisfaction with the information obtained from the system (O'Reilly, 1982; Rogers, 1983; Zmud, 1978). Because EDI affects not only the information itself but also the way in which the information is managed and used, it seems appropriate to expand the context of usefulness beyond the quality of the information component itself to include benefits derived from its use. Usefulness has been shown to be a major influence of post-adoption beliefs about a technology (Karahanna, Straub & Chervany, 1999; Torkzadeh & Doll, 1991). If users do not believe a technology is useful, they may refuse to use it.

The greater the expectations of what the system will provide (i.e., perceived benefits), the greater the users' ratings of its performance (Hoch & Ha, 1986; Oliver, 1977). In turn, perceived performance has been demonstrated to affect, even determine, the extent of satisfaction with the system (Yi, 1990). It is unlikely that users will be satisfied with a system for which they perceive few benefits (Iacovou et al., 1995). Therefore, the effect of users' perceptions of EDI-related benefits on user satisfaction with EDI is examined and the following hypothesis is proposed:

H1: The greater the perceived benefits of EDI, the more satisfied the users are with EDI.

Organizational Compatibility

Organizational compatibility encompasses the "availability of the needed organizational resources" to implement EDI (Iacovou et al., 1995, p. 467), as well as EDI's consistency with existing systems and norms. Users view innovations more favorably when they perceive them to be consistent with their present systems, values, practices, procedures, and norms (Reekers & Smithson, 1994). They are also more satisfied with systems that can be implemented with little disruption to the workplace (Rushinek & Rushinek, 1986). Users often view change negatively, and resistance to change is a major hinderance to successful EDI implementation and integration (Benjamin, deLong & Scott Morton, 1990; Emmelhainz, 1988). In spite of this, some firms are forced to adopt EDI by customers or by competitive pressures, even though they may not be fully ready to do so and even if EDI is unrelated to their current systems and/or practices (Helper, 1991; Kale, 1989; Webster, 1995; Wrigley, Wagenaar & Clarke, 1994). Because EDI alters not only the way processes are performed but often alters the routine way of doing business, its implementation may lead to resistance and ultimately to low satisfaction. Thus, the less alteration to the routine, the more satisfied users may be.

Thus, we propose the following hypothesis:

H2: The more compatible EDI is with existing systems and practices, the more satisfied the users are with EDI.

Changes in Users' Jobs

Davis (1989) suggests that users' attitudes toward a system are influenced by expectations about how it will impact their job. Information systems impose order, shaping and reinforcing the rules and norms that govern the way users' jobs are done (Orlikowski & Robey, 1991). Because EDI changes the way a process is done, an individual user's job is also changed (Banerjee & Golhar, 1994; Kumar & Crook, 1996). Although attitudes about an information system are linked to satisfaction, there is little evidence about the relationship between user satisfaction and the changes the system requires in the user's job (Barber & Lucas, 1983). However, as discussed earlier, user resistance to change can impede EDI success. Thus, the extent to which jobs are changed may influence user satisfaction with the system that required the changes. We propose the following hypothesis:

H3: The less change EDI creates in the users' jobs, the more satisfied the users are with EDI.

METHODOLOGY

Questionnaires were mailed to a systematic random sample of EDI representatives in 500 U.S. firms listed in the Uniform Code Council EDI Member Directory. To minimize bias and to ensure that the questions were given to the people who could supply the best answers, the EDI representative listed in the directory was asked to deliver the user questionnaire to the key user or contact person in sales, purchasing, and transportation/distribution. These areas were chosen because they are the most common areas for EDI implementation (Lummus & Duclos, 1995; Zack, 1994). The EDI representative was also asked to complete a short questionnaire about the length of time EDI had been used in the firm, the number of transactions and applications processed, and the number of EDI trading partners. The EDI representative was asked to return his/her questionnaire separately from the user.

This form of survey distribution probably reduced our response rate. A total of 67 usable user surveys were returned for a response rate of 13.4%. Although low, this response rate is consistent with that in other EDI-related studies (Teo et al., 1995) as well as in studies in which respondents at this level are surveyed (Ellis, Jones & Arnett, 1994). There are several reasons more may not have been returned. Some of the firms in the directory were no longer in business, and some of the EDI representatives were no longer at the firm, and their surveys were returned unopened. Approximately 22% more EDI representative surveys were returned than user surveys (81 EDI representative surveys), yet all but one of the user surveys could be matched to an EDI representative survey. This indicates that either the EDI managers did not pass on the user survey, or the users did not complete them. However, because results are based on responses of users in firms where the EDI manager did pass the user survey along, and the EDI manager completed his/her own survey, the findings may be biased toward firms in which the EDI manager and user work more closely together, the user is more interested in EDI, or the EDI manager is also the user. The latter is true for 15 of the respondents.

To assess whether respondents were different than nonrespondents, the two groups were compared on two characteristics listed in the Uniform Code Council EDI Member Directory–type of company and EDI standard used (Table 1). The vast majority of each group are manufacturing firms, yet there are proportionally more among the respondent group (64%) than the nonrespondent group (53%). There are also proportionally more retail firms among respondents (13% vs. 5%) and more

Table 1. Comparison of respondents with a random sample of non-respondents on type of company and EDI standard

Type of Company	Percent of Respondents	Percent of Non-respondents
Manufacturer	64	53
Retail	13	5
Wholesale	10	20
Broker	6	10
Distributor	3	5
Warehouse	2	5
Other	2	2
EDI Standard		
UCS	39	52
VICS EDI	59	43
WINS	2	5

wholesale firms among nonrespondents (20% vs. 10%). The remaining 13% of the respondents and 22% of nonrespondents are in distribution, warehousing, or brokerage firms.

Three EDI standards that are widely used in the U.S. were listed; Voluntary Inter-Industry Commerce Standard (VICS EDI), which is a standard used widely by retailers and their suppliers; Uniform Communications Standard (UCS),which is used widely by most other industry segments; and Warehouse Information Network Standard (WINS), which is used largely by warehouse firms. The VICS EDI standard was used by 59% of respondents and 43% of nonrespondents. On the other hand, 52% of nonrespondents use the UCS standard compared to 39% of the respondents. There were few using WINS in either group–which is to be expected because the proportion of warehouse firms was low in both groups. Thus, findings are more representative of manufacturers than any other type of company and of firms that use VICS EDI, suggesting that these firms deal largely with retailers.

PROFILE OF RESPONDENTS

In 15% of the firms, EDI had been in use no longer than one year, whereas it had been used at least five years in 67% of the firms. EDI had been in use between 1 and 5 years in the remaining 18% of firms. Some respondents had used EDI prior to joining their present firms, and others learned EDI because it was being used by these firms when they were hired. Only 21% had used EDI no more than 1 year; 45% had between 1 and 4 years experience; and the remaining 34% had used EDI more than 4 years.

Trading partner pressure strongly influenced the decision to adopt EDI (mean of 1.84 on a 5-point scale, where 1 is strongly agree external pressure influenced and 5 is strongly disagree), and the transactions converted to EDI are very critical to the firm (mean = 1.68; on a 5 point scale, where 1 is very critical and 5 is not very critical).

However, well over one-half (57%) of firms report that EDI is fully automated–there is no manual intervention anywhere in the processing of the transaction set. The other 43% indicate that they are still using manual intervention somewhere in the process.

Furthermore, 33% of these firms do EDI with 10 or fewer trading partners. Another 15.4% do EDI with between 11 and 20 other firms, and 10% have between 21 and 40 EDI partners. Another 19.8% have between 50 and 100 EDI partners, and the remaining 17.6% have over 100 partners. Thus, EDI appears to not be highly integrated in the network of trading partners or in the way these firms do business. Another indicator of the extent of EDI integration in a firm is the number of different applications for which they use EDI (e.g., purchase orders, invoices). Over 30% of the firms send at least five different types of transactions using EDI (31.7%), 9.8% send four, 22% send three, 29.3% send two, and only 7.3% indicate they send only one type of transaction. They receive more types than they send: 31.7% receive at least six different types of transactions. Another 12.2% receive five, 9.8% receive four, 17.1% receive three, and another 17.1% receive two. Only 9.8% receive only one type of transaction.

DATA ANALYSIS AND RESULTS

Factor Analysis

User responses were factor analyzed to assess the dimensionality of constructs in which multiple indicators were used. Means, standard deviations, and ranges of each of the 38 indicators are provided in Tables 2a, 2b, and 2c, and the correlations between each of the indicators are provided in Tables 3a and 3b. The means, standard deviations and ranges indicate that the responses to the items are well distributed across the scales, and therefore represent the broad variety of perspectives they were intended to measure. The correlations indicate that there are moderate to strong correlations between items proposed to measure a given construct and weak correlations between these items and those proposed to measure other constructs. This suggests that the items exhibit moderate to strong convergent and discriminant validity (Hair, Anderson, Tatham & Black, 1992). One exception is the set of items to measure "impact on users' jobs" (29-38). In particular, items 34-38 are weakly correlated with that item set, as well as all other items. Thus, these are weak in convergent validity and may not be good indicators of the construct. Factor analysis was used to further examine the strength of these 38 items.

A separate factor analysis was conducted for each construct, rather than one factor analysis in which the loadings of each indicator on several factors are examined. Factor analyzing all 38 indicators simultaneously would result in a correlation matrix of over 700 relationships and, thus, would not produce meaningful or reliable results. Because each construct is grounded in theory and the scales have been used in other contexts, we believe the risk of items serving as indicators of other proposed constructs is minimized. Thus, we believe a factor model that tests hypotheses about the indicators of individual constructs rather than a model that tests hypotheses about the number of factors is appropriate.

Two other criteria guided the choice to proceed with individual factor analyses; widely accepted rules-of-thumb about sample size and number of variables, and empirical evidence about magnitude of loadings. It is suggested that there be at least 4 or 5 times as many observations as variables (Hair et al., 1992). A sample size of at least 50 is also recommended, although larger samples are better (Hair et al.). Because our sample size is 67 and there are no more than 12 variables in any factor, these criteria are met. However, a Monte Carlo study indicates that component saturation (absolute magnitude of the factor loadings) is often a better indicator of the strength of the factor, in some cases irrespective of the number of observations (Guadagnoli & Velicer, 1988). For example, a factor with four or more loadings above 0.60 is considered a reliable factor regardless of sample size. However, the empirical evidence provided by the Monte Carlo study doesn't address exceptions (e.g., three loadings greater than 0.60 and four greater than 0.50), and interpretations of these cases remain largely driven by rules-of-thumb and by theoretical considerations (Stevens, 1992). Therefore, we used the Monte Carlo study as an ex post facto guide in assessing the strength of the resulting factors. Based on the rules-of-thumb and the ex post facto analysis, we believe that this sample is sufficient to allow adequate interpretation of the factor structure resulting from the individual factor analyses.

A principal factors analysis, using varimax rotation, with prior communality estimates set equal to squared multiple correlations (SMC) was used. Eigenvalues, percent of variance explained, and factor loadings were used to assess dimensionality of the factor and the appropriateness of the indicator. When using SMCs to estimate the initial communalities, the rule-of-thumb for choosing factors having eigenvalues of at least 1 is inappropriate (Hair et al., 1992). However, it is appropriate to examine the difference in eigenvalues between factors. In each analysis, there

Table 2a: Means and standard deviations of indicators

Item #	Indicator	μ	σ	Range *
1	Precision of Information	3.94	1.00	1 to 5
2	Information Content	3.98	0.96	1 to 5
3	Reports	3.45	1.16	1 to 5
4	Sufficient Information Provided	3.96	0.96	1 to 5
5	Actual Accuracy of Information	4.34	0.73	1 to 5
6	Satisfaction With Accuracy	4.33	0.84	1 to 5
7	Output Format	3.97	1.09	1 to 5
8	Information Clarity	4.02	0.95	1 to 5
9	User Friendliness of System	3.58	1.23	1 to 5
10	System Ease of Use	3.69	1.12	1 to 5
11	Timeliness of Information	4.16	0.83	1 to 5
12	How Up-to-Date Reports Are	4.19	0.85	1 to 5

* Indicators were measured on a 5-point scale where 1=low satisfaction and 5=high satisfaction.

Table 2b: Means and standard deviations of indicators

Item #	Indicator	μ	σ	Range*
13	Reduced Transaction Costs	2.78	0.98	1 to 5
14	Improved Cash Flow	2.90	0.75	1 to 5
15	Reduced Inventory Costs	3.08	0.92	1 to 5
16	Improved Information Quality	2.16	0.76	1 to 5
17	Improved Internal Operations	2.35	0.86	1 to 5
18	Enabled Improved Customer Service	2.23	0.86	1 to 5
19	Improved Trading Partner Relations	2.12	0.80	1 to 5
20	Increased Firm's Ability to Compete	2.00	0.88	1 to 5
21	Disrupted Workplace, at first	2.56	1.14	1 to 5
22	Required Changes in Operating Procedures	1.98	0.90	1 to 4
23	Decreased Productivity, at first	2.70	1.07	1 to 5
24	Required Substantial Time to Learn	2.80	1.19	1 to 5
25	Required New Hardware/Software	2.12	0.94	1 to 5
26	Required Increased Computer Support	2.30	0.96	1 to 5
27	Required Substantial Site Preparation	2.98	1.02	1 to 5
28	Required Modifications to Existing Systems	2.23	0.89	1 to 4

* Indicators were measured on a 5-point scale where 1=strongly agree and 5=strongly disagree.

Table 2c: Means and standard deviations of indicators

Item #	Indicator	μ	σ	Range*
29	Importance of User's Job	2.08	0.77	1 to 3
30	Work Required	2.65	1.22	1 to 5
31	Accuracy Required	2.23	0.87	1 to 4
32	Necessary Job Skill Requirements	2.25	0.70	1 to 4
33	Verification of Document Authenticity	2.85	0.80	1 to 5
34	Control Needed for Documents	2.66	0.80	1 to 4
35	Freedom in Job Performance	2.70	0.74	1 to 5
36	Interaction With Trading Partners	2.27	0.67	1 to 4
37	Relationships with Colleagues	2.67	0.54	1 to 4
38	Amount of Paperwork Processed	3.25	1.11	1 to 5

* Indicators were measured on a 5-point scale where 1=greatly increased and 5=greatly decreased.

was a substantial difference between the eigenvalue for the factor(s) retained and those not retained. Furthermore, at least 78% of the variance was explained in each case. Finally, only items with factor loadings of at least .40 were retained (Hair, et al., 1992). Cronbach's alpha was used to assess internal consistency, using Nunnally's (1978) criteria that constructs with alpha of at least .70 are internally consistent. Final factor loadings for each construct and its respective Cronbach's alpha are provided in Table 4.

Factors 1, 2, and 3 were all unidimensional and consistent with expectations. In addition, Factors 1 and 2 met Guadagnoli and Velicer's (1988) criteria for

Table 3a: Correlation matrix for the original 38 items

Item	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	1.00																			
2	.85	1.00																		
3	.68	.60	1.00																	
4	.65	.71	.70	1.00																
5	.42	.55	.46	.52	1.00															
6	.47	.59	.44	.45	.87	1.00														
7	.56	.59	.58	.58	.55	.57	1.00													
8	.56	.57	.55	.56	.52	.51	.83	1.00												
9	.44	.48	.49	.59	.48	.44	.73	.70	1.00											
10	.46	.49	.40	.48	.49	.50	.70	.68	.88	1.00										
11	.60	.65	.44	.60	.63	.61	.65	.67	.65	.68	1.00									
12	.68	.69	.55	.67	.62	-.13	.67	.65	.54	.58	.82	1.00								
13	-.29	-.31	-.26	-.42	-.14	-.24	-.15	-.24	-.33	-.20	-.28	-.20	1.00							
14	-.47	-.37	-.32	-.42	-.16	-.01	-.20	-.22	-.34	-.29	-.43	-.29	.52	1.00						
15	-.34	-.25	-.36	-.43	-.02	-.04	-.09	-.04	-.21	-.10	-.20	-.22	.56	.52	1.00					
16	-.42	-.36	-.32	-.36	-.05	-.06	-.37	-.24	-.32	-.22	-.23	-.35	.32	.36	.36	1.00				
17	-.33	-.35	-.22	-.31	.02	-.06	-.40	-.25	-.42	-.40	-.37	-.27	.34	.37	.29	.57	1.00			
18	-.13	-.12	-.17	-.36	.04	.01	-.25	-.27	-.42	-.25	-.15	-.13	.53	.33	.32	.45	.44	1.00		
19	-.22	-.23	-.27	-.28	.05	-.05	-.34	-.21	-.32	-.10	-.19	-.26	.42	.36	.31	.52	.48	.61	1.00	
20	-.36	-.22	-.13	-.21	.06	.05	-.23	-.15	-.15	-.13	-.22	-.33	.25	.23	.25	.52	.45	.47	.55	1.00
21	.31	.20	.24	.07	.13	.15	.23	.20	.21	.22	.20	.17	-.03	-.05	-.14	-.16	-.22	-.04	-.13	-.20
22	.19	.11	.25	-.02	.16	.16	.14	.15	.25	.38	.11	.14	.23	.13	.19	.19	.05	.18	.20	.02
23	.18	.13	.13	-.02	.02	.09	.16	.24	.26	.28	.15	.09	-.02	-.04	-.09	-.06	-.29	-.18	-.25	-.23
24	.10	.03	.03	-.16	.06	.05	.07	.18	.16	.22	.08	.03	-.00	.01	.03	-.07	-.16	-.12	-.06	-.13
25	.26	.28	.23	.23	.20	.21	.25	.27	.32	.42	.28	.26	-.12	-.00	-.09	.04	-.18	-.12	-.06	.04
26	.14	.19	.20	.25	.22	.25	.29	.28	.32	.36	.20	.11	-.12	-.10	-.18	.03	-.17	-.15	-.12	.07
27	.01	.03	.05	.02	.25	.14	.17	.08	.06	.09	.04	.06	-.02	.02	.07	-.06	-.07	-.08	-.08	.02
28	.07	0.04	.03	-.07	-.01	-.07	.00	.14	.15	.24	.12	-.00	-.13	-.09	.02	.15	-.08	-.02	.06	.03
29	-.06	-.15	-.20	-.31	-.16	-.19	-.21	-.16	-.15	.00	-.07	-.10	.32	.26	.11	.38	.19	.34	.51	.23
30	.10	.06	.15	.01	-.12	-.10	.08	.03	.19	.29	.03	.03	-.02	.08	-.16	-.00	-.24	-.06	.07	.05
31	-.07	-.16	.03	-.23	-.21	-.20	-.12	-.09	-.09	-.07	-.16	-.08	.18	.14	-.06	.07	-.00	.08	.05	.08
32	-.04	-.15	.18	-.11	-.11	-.17	-.10	.06	-.03	-.02	-.08	-.10	.18	.23	.01	.18	.20	.04	.15	.15
33	-.06	.03	.08	-.13	-.00	-.00	.02	-.03	-.00	.05	.06	.02	.03	.06	-.18	.00	-.19	.00	-.02	-.04
34	.04	.09	-.04	-.15	-.04	-.03	.00	.02	.09	.22	.12	.06	.01	-.02	-.20	.00	-.17	.07	.20	.00
35	.01	.06	-.08	-.13	-.00	-.07	-.09	-.16	-.27	-.15	.04	.03	.27	.23	.02	.15	.21	.42	.23	.17
36	.16	.10	-.08	-.12	.11	.05	-.15	.04	-.16	.00	.09	.09	.23	.18	.24	.25	.20	.43	.56	.19
37	.15	.04	.10	.02	.05	-.02	-.11	.03	-.23	-.22	-.02	-.06	.33	.14	.22	.29	.40	.42	.40	.16
38	.12	.17	.17	.10	-.08	-.02	.17	.02	.20	.12	.07	-.06	-.19	-.14	-.20	-.19	-.30	-.20	-.28	-.16

*Table 3b: Correlation Matrix for the Original 38 Items**

Item	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38
21	1.00																	
22	.37	1.00																
23	.61	.35	1.00															
24	.43	.28	.69	1.00														
25	.31	.44	.33	.08	1.00													
26	.23	.27	.27	.21	.60	1.00												
27	.30	.12	.32	.32	.32	.29	1.00											
28	.11	.28	.25	.24	.40	.29	.11	1.00										
29	.20	.46	.04	.13	.21	.14	.36	.31	1.00									
30	.20	.34	.30	.29	.43	.30	.18	.36	.47	1.00								
31	.20	.29	.30	.27	.08	.07	.25	.18	.48	.43	1.00							
32	.25	.43	.28	.29	.15	.08	.00	.25	.50	.52	.51	1.00						
33	.20	.20	.28	.26	.16	.04	.06	.00	.19	.47	.25	.43	1.00					
34	.04	.19	.18	.24	.24	.13	-.06	.06	.32	.45	.33	.28	.67	1.00				
35	.03	.05	-.09	.04	.02	.03	.17	-.06	.25	.03	.06	.08	.27	.08	1.00			
36	-.16	.32	-.14	.06	.10	-.03	-.03	.17	.46	.05	.16	.22	.01	.18	.34	1.00		
37	-.02	.10	-.18	-.10	-.00	-.01	.09	-.14	.38	.08	.11	.32	-.04	.02	.22	.45	1.00	
38	.18	.07	.15	.02	.18	.13	.09	-.01	.09	.46	.04	.20	.39	.19	.19	-.18	-.02	1.00

* Items 1 - 12 are designed to indicate user satisfaction
Items 13 - 20 are designed to indicate perceived benefits
Items 21 - 28 are designed to indicate organizational compatibility
Items 29 - 38 are designed to indicate impact of EDI on users' jobs

Table 4: Final results of individual factor analyses

Factor information*	Factor Loading
Factor #1 — User Satisfaction (α = .95) **Eigenvalue = 7.35; 79% variance explained**	
How up-to-date reports are	.84064
Timeliness of information	.83771
Output format	.83217
Information content	.81061
Information clarity	.80501
User friendliness of system	.78163
How easy to use the system is	.77603
Sufficient information provided	.76719
Precision of information	.76686
Actual accuracy of information	.73611
Satisfaction with accuracy	.73072
Reports	.69549
Factor #2 — Benefits (α = .86) **Eigenvalue = 3.47; 95% variance explained**	
Improved trading partner relationships	.72230
Enabled improved customer service	.70341
Improved information quality	.69042
Reduced transaction costs	.67145
Improved internal operations	.66259
Improved cash flow	.63318
Increased firm's ability to compete	.60675
Reduced inventory costs	.56370
Factor #3 — Organizational Compatibility (α = .78) **Eigenvalue = 2.33; 84% variance explained**	
Decreased productivity, at first	.79217
Disrupted the workplace, at first	.65097
Required substantial learning time	.63022
Required new hardware/software	.58086
Required changes in operating procedures	.52943
Required increased computer support	.51169
Factor #4 — Impact on User's Job: Tasks (α = .76) **Eigenvalue = 2.17; 62% variance explained**	
Verification of document authenticity	.78973
Amount of work required	.68264
Control needed for documents	.67577
Amount of paperwork processed	.52838
Factor #5 — Impact on User's Job: Relationships (α = .67) **Eigenvalue = 1.26; 36% variance explained**	
Communication with trading partners	.73982
Importance of user's job	.62964
Relationships with colleagues	.55775
Freedom to do the job	.40275

* Factors 1-3 were derived in 3 separate exploratory factor analyses; Factors 4 & 5 were derived from a single exploratory factor analysis. Thus, 4 separate exploratory factor analyses were used to derive these 5 factors.

component saturation. They each had more than four factor loadings greater than 0.60. Factor 3 had three loadings greater than 0.60 and three other strong loadings (above 0.50). All 12 indicators of *user satisfaction* were retained, accounting for 79% of the variance, with an internal consistency of 0.95. Although Doll and Torkzadeh indicate that these items represent five orthogonal factors rather than one, these results are consistent with Chin and Newsted's (1995) findings that the factors are not orthogonal, but are highly correlated. Others have also found that the items represent fewer than five factors (Seddon & Yip, 1992). Furthermore, Cronbach's coefficient alpha is consistent with that calculated by Torkzadeh and Doll (1991) for the complete 12-item scale.

All eight indicators of *perceived benefits* were retained, accounting for 95% of the variance, with an internal consistency of 0.86. The eight indicators of *organizational compatibility* were originally thought to represent two different dimensions–technical compatibility and operational compatibility. However, the factor loadings and eigenvalues indicate that there is only one underlying factor for this data set. All eight indicators were retained, accounting for 82% of the variance. Perhaps the difference lies in differing perspectives between users of a technology and technical supporters of it. Other studies in which two dimensions of compatibility were proposed addressed only the perspective of managers and EDI personnel not the end users.

Impact on the user's job has two underlying dimensions: tasks and relationships. Retaining only one factor results in low factor loadings (less than 0.40) for several items and strong cross-loadings for others. This, Coupled with the fact that two factors explained 98% of the variance, supports a two-factor model. Four items for each of the two factors were retained. However, *job impact: relationships* has a Cronbach's alpha of less than .70. Thus, it was not included in subsequent analysis.

Regression Analysis

Because factor loadings indicate that the sets of items for each factor retained exhibit strong convergent validity, the raw data values of the sets of indicators for each factor retained in the factor analysis were averaged to form their respective constructs (Bagozzi & Yi, 1988; Hair et al., 1992). These constructs were then used in multiple regression analysis, rather than the individual items, to test the hypotheses (Hair et al.). Results are presented in Table 5.

Table 5: Regression analysis results (Overall $F = 6.13$; $p = .0011$; $R^2 = .25$)

Independent variable	**Student's t-value (p)**	**Beta**	**Expected direction**
Benefits*	3.23 (.0021)	0.51	+
Organizational Compatibility	2.44 (.0181)	0.33	+
Job Impact: Tasks*	0.54 (.5910)	0.07	+

* Reverse-coded prior to analysis.

Two of the three hypotheses were supported: the more benefits that are perceived to result from EDI, the more satisfied the user (H1); and the more compatible EDI is, the more satisfied the user (H2). The model explains 25% of the variability in user satisfaction with EDI, which can be considered quite good when attempting to capture user satisfaction.

Impact on the job: tasks did not significantly impact user satisfaction (H3). Perhaps these users were not working in the area at the time EDI was implemented, thus job impact has no effect on them. Another possible explanation is that the changes have been in effect long enough to have been accepted and/or forgotten. Thus, time could be a mediating factor in the effect of EDI precipitated changes to an individual's job and his/her satisfaction with EDI. Further research is needed to better assess job impact.

CONCLUSIONS, IMPLICATIONS, AND DIRECTIONS FOR FUTURE RESEARCH

This study examines a model in which three possible antecedents of user satisfaction with EDI are examined; perceived benefits, organizational compatibility, and impact on user jobs. Findings support the proposal that when users perceive that EDI is beneficial to the firm, they are more satisfied. Findings also indicate that the less change an organization must implement, or the more compatible EDI is with organizational systems and practices, the more satisfied the user. Thus, firms considering EDI or those that are beginning to integrate EDI should begin user education about EDI as early as possible. Users must understand how this method of doing business is beneficial and, if there are changes to be made, why they are important. In addition, before adopting EDI, a firm may want to plan the implementation to allow changes to be assimilated into the users' environment. Furthermore, firms could involve users in the changes early in the adoption/implementation process in order to gain their support.

Firms for which EDI is a radically different way of doing business or firms that are not organizationally ready to adopt may also need more support from customers when customers require that they become EDI-capable. Customers should keep this in mind as well. If users aren't satisfied with the system, the effectiveness of the system may be diminished, affecting not only the adopting firm, but also the trading partners who are dependent on that firm.

User satisfaction with EDI is a little-explored subject. However, because EDI is an interorganizational system, the impact of its effectiveness is not limited to one firm. Thus, the impact of user satisfaction is no longer contained in one system or one firm. Its importance is magnified throughout the group of trading partners using the system–very possibly entire industries in the near future. Furthermore, given the strategic nature of EDI in many firms, learning about user satisfaction with EDI is important not only to the success of an individual system, but in many cases, it may be important to the success of an entire business.

EDI is one example of interorganizational systems that firms are using to form tighter linkages to respond to competitive pressure to more tightly link the adjacent steps of the value chain and to electronically transmit business transactions (Zwass, 1999). Issues such as user satisfaction, system compatibility, perceived benefits, and impact on jobs may also apply to other types of interorganizational systems (IOSs) such as Web-based business-to-business transaction systems. Thus, findings in this study not only enhance the basis on which to build an understanding of the user role in EDI success, but also on which future research may be conducted to examine the role of these variables in the success of other IOSs.

The results from this study also provide several directions for additional research on end-user satisfaction of information systems technologies. Although the antecedents selected for the research model provide valuable insights into end-user satisfaction with EDI, this initial framework may not have captured all of the salient factors important to end-user satisfaction of this, or other, IOS technology. For example, cognitive or behavioral variables such as computer efficacy or attitudes toward computers, as well as organizational variables such as structure, size, IT maturity, and organizational culture, have been shown to influence user satisfaction with information systems technologies (e.g., Davis, 1989; ; DeLone & McLean, 1992; Etezadi-Amoli & Farhoomand, 1991; Franz & Robey, 1986). These may play a role in user acceptance of e-business technologies such as EDI. Subsequent studies using an expanded user satisfaction framework may provide a richer understanding of factors that contribute to EDI system success and acceptance by members of the user community.

Another research direction suggested by this study is to expand the scope of the study to research beyond only EDI technology. The findings from this study may serve as the basis for future empirical studies on end-user satisfaction of other related interorganizational or e-commerce technologies. Future research is needed to examine whether the findings from this study are consistent across related technologies. Past studies seem to indicate that it is difficult to generalize user satisfaction models across multiple information systems technologies due to inherent textual and operational characteristics that are unique to each technology. Additional research is needed to assess the robust nature of this user satisfaction model.

Finally, this study attempted to measure user satisfaction of EDI by assessing the perceptions of a single end-user within an organization. This single respondent research methodology may not provide an accurate organizational view of end-user satisfaction with EDI because EDI is used by a number of end users within distinct organizational functional areas (e.g., customer support, accounts payable, transportation, etc.). Future research could examine the perceptions of multiple respondents from each of the functional areas that use EDI to obtain a broader analysis of end-user satisfaction within the organization. This would also allow researchers to identify similarities and differences among end users in each business function. Findings from this type of study could greatly enhance our knowledge of the factors that contribute to technology acceptance and success within dynamic organizations.

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Chapter XIII

Corporate Intranet Infusion

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Using intranets to connect heterogeneous systems enables information sharing between existing information systems without major changes to existing applications. Corporate intranets provide the supporting infrastructure for Web publishing, collaborative applications, and line of business applications. This study examined organizational, contextual, and technical variables that are associated with intranet infusion in organizations. A survey was mailed to 1,000 senior-level computer executives in the United States. Six independent variables were examined using an ordered probit analysis to explain the likelihood of occurrence for different levels of intranet infusion. Results indicate that top management support, IT infrastructure, and competition positively influence high levels of intranet infusion. Organizational size is negatively associated with high levels of intranet infusion. Implications and areas for further research are discussed.

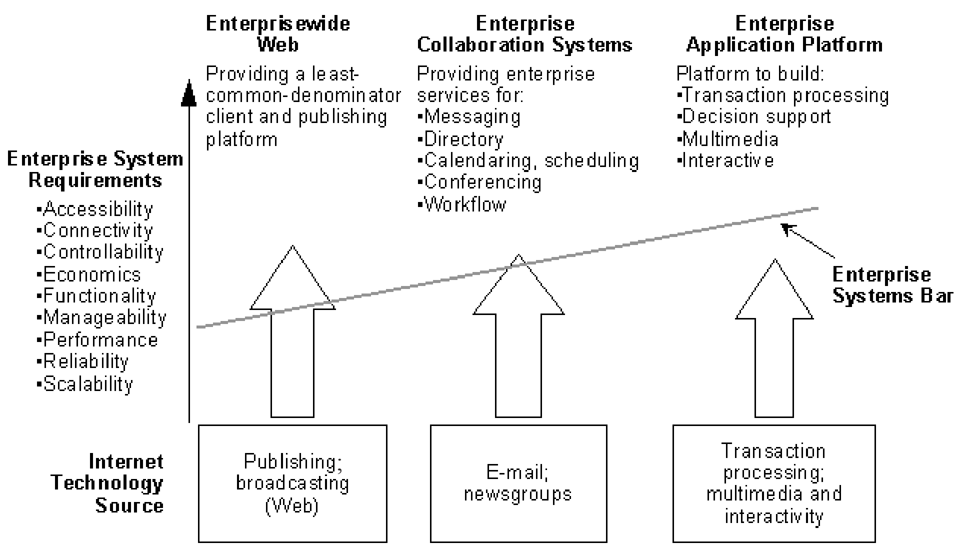
INTRODUCTION

Intranets provide heterogeneous system connectivity, multi-platform access to multimedia information, and a single, common user interface to many different applications. Corporate intranets provide the supporting infrastructure for Web publishing, collaborative applications, and line of business applications. Reports indicate that corporate intranets provide quantifiable benefits including immediate access to information that is cost-effective, up-to-date, as well as versatile (Baker, 2000). By the year 2000, intranets were installed in more than 95% of early technology adopter organizations, 80% of the mainstream technology adopter organizations, and 60% of the conservative technology adopter organizations (Claps & Phifer, 1999). Corporate spending on intranets worldwide reached $64 billion in 2001 and is expected to reach $200 billion annually by 2010 (McCarty, 2001).

Intranet deployments can be categorized into three levels of integration with organizational processes. The Gartner Group (1996) defines three intranet platforms that are useful to categorize these levels of deployment. These platforms are the enterprise-wide Web (EWW), the interactive collaboration platform (ICP), and the interactive application platform (IAP). Each platform is based on the complexity of its applications. EWW is the easiest form of intranet to deploy because it involves very little technical knowledge to implement. Using basic HTML-based Web pages, existing "islands of information" can be seamlessly connected for enterprise-wide access. ICP extends the publishing model by adding an on-line medium for collaboration and group work. The third level of intranet deployment, IAP, provides interactive access to line of business (LOB) applications and databases. Existing legacy applications and data warehouses are accessed seamlessly through a Web browser, providing a single common user interface. As can be seen in Figure 1, intranets have the potential to support enterprise applications such as transaction processing, decision support systems and highly distributed multimedia applications. As intranets progress through the levels of integration defined above, the requirements increase enormously for incorporating enterprise systems' attributes (Claps & Phifer, 1999).

The present research views an intranet as a technological innovation (Zmud & Apple, 1992) that has been adopted and implemented by an organization. The study draws from the IS implementation literature (Kwon & Zmud, 1987) to explain the relationship between the organization and the implementation process of a new IT or technological innovation. Its objective is to explore which organizational, contextual and technical factors contribute to or detract from intranet infusion in organizations.

Figure 1: Evolution of intranet deployment (source: Gartner Group)



IS IMPLEMENTATION LITERATURE

Kwon and Zmud (1987, p. 231) define IS implementation as "an organizational effort to diffuse an appropriate information technology within a user community." In 1987, Kwon and Zmud conducted an extensive review of the IS implementation literature and developed a coherent model that encompassed two decades of fragmented research streams. Based on the concepts of Lewins' (1952) Change model, Kwon and Zmud's model includes 6 stages of IS implementation: initiation, adoption, adaptation, acceptance, use, and incorporation. Several research studies emerged from Kwon and Zmud's model to examine the introduction of technological innovations into organizations (Cooper & Zmud, 1990; Kwon 1991; Zmud & Apple, 1992). Cooper and Zmud studied the interaction of task and technology characteristics on the adoption and infusion stages of the IS implementation process of a technological innovation where a single task was affected by the introduction of the innovation. Infusion was said to occur when the technological innovation is used within the organization to its fullest potential. Their results suggested that while rational decision models can be useful in explaining information technology adoption, future models that include organizational factors might provide stronger support for factors leading to information technology infusion. Kwon extended the work of Cooper and Zmud to organizational communication network behaviors as well as MIS maturity. His findings suggested that the relationship between the work unit and MIS also affects the success of information technology infusion. Zmud and Apple found that an information technology can be diffused within an organization without necessarily being infused, or utilized to its fullest potential. Further, they state that there are measurable events that occur as a technological innovation is infused into organizations. The infusion of a technological innovation consists of a succession of technological configurations that relate directly to a series of new work patterns within an organization. Each new level of infusion incrementally builds onto existing functionality from the prior levels. With each increasing technological configuration, the interconnectedness of work flows within the organization increases.

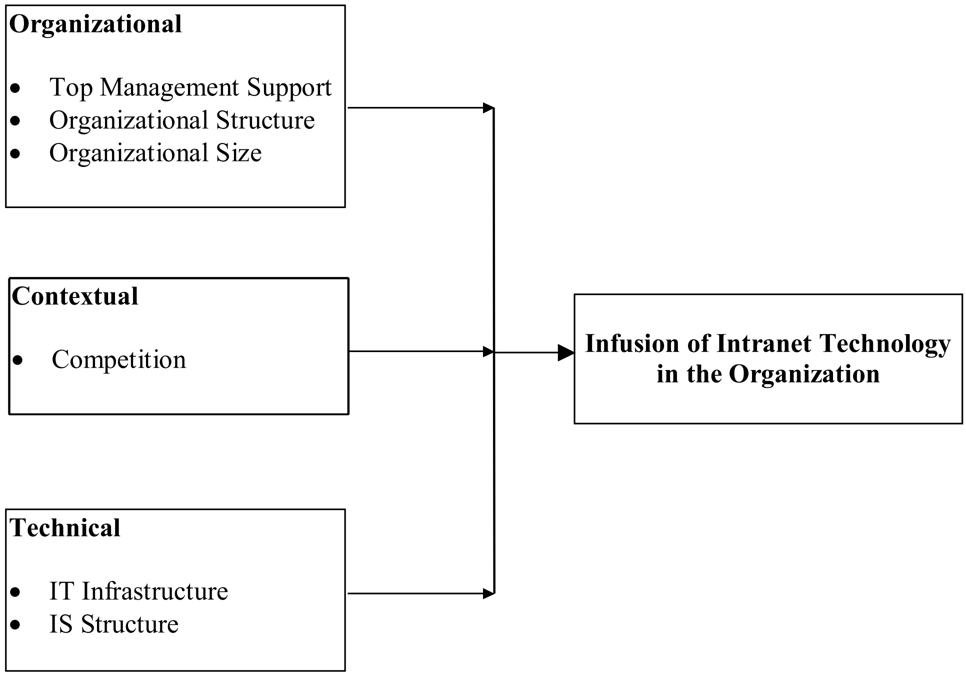
RESEARCH MODEL AND HYPOTHESES

This study continues to extend the work of Kwon and Zmud (1987) by examining infusion as an element of the incorporation stage in the IS implementation process. Figure 2 presents the research model in which organizational, contextual, and technical variables are examined in their relationships to the infusion of an organization-wide information technology.

Dependent Variable: Intranet Infusion

The three levels of intranet deployment, EWW, ICP and IAP, can be related to the measurable events of technological innovation infusion described by Zmud and Apple (1992). At the Web publishing level (EWW), organizational information is posted electronically in the form of static pages and the intranet is used for "one-way"

Figure 2: Research model



information sharing. The second level, the collaborative level (ICP), adds tools that allow employees to interact electronically via the intranet, fostering communication and idea sharing. At the third level (IAP), the intranet interface becomes a standardized interface for interactive line of business applications. Each level builds on the prior level by adding additional functionality that increases the interconnectedness of organizational work flows. The three levels correspond to low (EWW), medium (ICP), and high (IAP) levels of infusion as defined by Zmud and Apple (1992).

INDEPENDENT VARIABLES

Six variables are examined to assess their relationship to intranet infusion. They are top management support, organizational structure, organizational size, competition, IT infrastructure, and IS structure.

Top Management Support: Top management values are usually associated with their attitudes toward change (Kwon & Zmud, 1987). In the innovation literature, there is evidence to suggest that top management support is positively related to the adoption and use of new technologies among organizations (Kimberly & Evanisko, 1981; Tornatzky & Fleisher, 1990). In the IS literature, significant positive associations have been made between top management support and information technology implementation success (Fuerst & Cheney, 1982; Ives & Olson, 1984; Sanders & Courtney, 1985). When positive top management attitudes regarding a new technology have been communicated to users, there is a greater likelihood of implementation success (Damanpour, 1991). It is expected that:

H1: Top management support will be positively associated with the infusion of intranet technology within an organization.

Organizational Structure: Organizational structures are often defined in terms of their centralization. Centralization refers to the degree of concentration of organizational decision making (Kwon & Zmud, 1987). More concentrated decision-making is associated with a centralized organizational structure, whereas widespread participation in decision making occurs in decentralized organizations (Cohn & Turyn, 1980). Most studies have found centralization to be negatively associated with information technology innovation adoption and usage (Cohn & Turyn; Damanpour, 1991; Julien & Raymond, 1994; Zmud, 1982), although some positive associations have also been reported (Kimberly & Evanisko, 1981). Greater levels of decentralized decision-making appear to promote innovation (Cohn & Turyn, 1980). The implementation and use of an intranet is an organization-wide event. Because there is a greater need for information sharing in decentralized organizations, it is hypothesized that:

H2: Organizations that are decentralized will have higher levels of intranet infusion than organizations that are centralized.

Organizational Size: Organizational size has often been associated with the adoption and use of information technology (DeLone, 1981; Kimberly & Evanisko, 1981; Lind, Zmud, & Fisher, 1989; Moch & Morse, 1977). DeLone found that larger organizations used computer technology for a longer period of time than smaller ones, suggesting that larger firms are earlier adopters of new technological innovations than smaller firms are. Moch and Morse considered the causal relationship between organizational size and IT adoption, suggesting that the adoption of information technology is positively related to firm size. Kimberly and Evanisko reported similar results but point out that the directionality of the relationship is not always easily defined. The higher the level of intranet infusion, as defined by the Gartner Group (1996), the more interactive the intranet becomes. Larger organizations would be most likely to benefit from higher levels of intranets because they store a large amount of information on computer-based information systems. Because larger organizations generally have greater resources to invest in the adoption of a new technology, it is reasonable to expect that they would also be more likely to use a technology that could improve the effectiveness of information accessibility and sharability. Therefore,

H3: Organizational size will be positively related to the infusion level of intranets in an organization.

Competition: Market concentration refers to the percentage of an industry's output that is contributed by its four largest firms. The higher the concentration, the more the industry is dominated by a few firms. Positive relationships have been found between competition and the adoption and use of technological innovations (Iacovou, Benbasat & Dexter, 1995; Kimberly & Evanisko, 1981; Levin, Levin & Meisel, 1987). While Levin et. al. (1987) found that more intense competition resulted in higher adoption rates; Kimberly and Evanisko (1981) found that competition was positively related to the use of the technological innovation as well. As organizational knowledge is one of the most valuable competitive assets of a firm today, we expect that organizations in a more competitive environment would be more likely to use intranet technology to its fullest potential; that is, they would have higher levels of intranet infusion. It is hypothesized that:

H4: Organizations in a more competitive market will have higher levels of intranet infusion than organizations in a less competitive market.

IT Infrastructure: An IT infrastructure has been defined as "a set of shared, tangible, IT resources that provide a foundation to enable present and future business applications" (Duncan, 1995, pp. 39-40). Duncan found that unique characteristics of an IT infrastructure could be used to measure its flexibility. Among her findings was that a more flexible IT infrastructure is causally and positively related to the service capabilities of an information system. It is expected that a more flexible IT infrastructure will result in greater service offerings of the intranet; that is, higher levels of infusion throughout the organization. Therefore,

H5: Organizations with more flexible IT infrastructures will have higher levels of intranet infusion than organizations with less flexible IT infrastructures.

IS Structure: IS structure is generally defined as being either centralized, decentralized, or a hybrid of the two (Brown & Magill, 1994). Dixon and John (1989) classified IS functions into two distinct groups: management of technology and management of use of technology. Management of technology responsibilities focus on the macro-level issues concerning organizational computing such as operations and networking, whereas management of use of technology is focused on end-user computing and application development. The present research suggests that a hybrid structure would be most compatible with the successful implementation of a corporate intranet. Most of the trade literature suggests that intranet applications are being developed in departments by end users (Field, 1997; Gartner Group, 1996). The perceived value of the intranet to many departmental managers is that they can create and manage their own information and its availability for organization-wide access. A hybrid IS structure, one in which both IS and end users participate in designing and developing intranet applications, would be most likely to have the greatest infusion level of the technology. The following hypothesis is offered:

H6: Organizations with hybrid centralized/decentralized IS departments will have higher levels of intranet infusion than organizations with centralized IS departments or decentralized IS departments.

METHODOLOGY

Following a pilot survey to test the instrument, a large cross-sectional field survey was conducted to collect data about intranet implementations from senior-level computer executives of 1,000 business organizations across the United States. The sample came from the Directory of Top Computer Executives, published by Applied Computer Research, Inc. (Arizona). A total of 422 completed surveys were returned (42%), and 281 of those were from organizations that had intranets. The usable response rate was approximately 28%. Table 1 presents descriptive characteristics.

Overall, 59% of the organizations were from the service sector, and 41% from the manufacturing sector. All regions of the United States were adequately represented. Although the largest percentage (24.6%) of respondents was from organizations with 10,000 employees or more, all organizational sizes were satisfactorily represented.

Table 1: Characteristics of respondents

Industry Type	
Service:	
Medical	6.0%
Law	0.4%
Government	10.7%
Education	13.2%
Consulting	1.8%
Banking	6.0%
Other Service	23.5%
Manufacturing:	
Pharmaceutical	1.1%
Consumer Goods	4.2%
Electronics	1.1%
Computer Equipment	5.3%
Other Manufacturing	26.7%
Total	100%

IS Budget	
Under $1 Million	7.8%
$1-2 Million	11.7%
$2-4 Million	13.2%
$4-6 Million	8.2%
$6-8 Million	6.4%
$8-10 Million	5.3%
$10-20 Million	12.5%
Over $20 Million	31.0%
Not sure	3.9%
Total	100%

Respondent's Job Title	
Director, Networking	7.1%
Director, MIS	32.3%
Networking Manager	7.1%
MIS Manager	21.4%
CIO	18.1%
Other	13.8%
Total	100%

Number of Employees	
Less than 250	3.9%
250-499	8.9%
500-749	6.8%
750-999	8.2%
1,000-2,499	18.5%
2,500-4,999	17.1%
5,000-9,999	12.1%
10,000 or more	24.6%
Total	100%

Measures

Infusion: Using the 3-tiered infusion levels proposed by Zmud and Apple (1992) and the 3 levels of intranet deployment defined by the Gartner Group (1996), infusion was operationalized by providing respondents with definitions of intranet deployment levels and asking them to indicate the highest level of intranet application for each department.

Top Management Support: Items were developed specifically for this project using 5-point Likert-type scale items. Four questions were asked about the CEO's perceptions and communication of support for the organization's intranet.

Organizational Structure: Using a 5-point Likert-type scale, two questions were adapted from scales developed by Moore and Benbasat (1991) and Zmud (1982) to measure the degree of centralization of management decision-making in the firm.

Organizational Size: A scale developed by Straub (1989) was adopted to measure organizational size based on the number of employees in the organization.

Competition: Competition was measured with a single 5-point Likert-type scale item that asked respondents to rate how competitive they perceived their industry to be.

IT Infrastructure: Seven 5-point Likert-type scale items were adapted from Duncan (1995) to determine the degree of complexity in incorporating intranet technology.

IS Structure: Five 5-point Likert-type scale items were used to determine whether the end-user departments, the IS department, or a hybrid effort was responsible for the intranet.

RESULTS

Table 2 shows the means, standard deviations, alphas and descriptions for each of the variables in the study. The multi-item measures used in this study were adapted rather than adopted in their original form. A reliability analysis demonstrated that they all had alphas above the recommended .60 for nonvalidated scales (Nunnally, 1978), providing a suitable level of internal consistency and reliability for each of the scales.

A principal component analysis with varimax rotation specifying a 4-factor solution was performed. The results of the factor analysis, with high loadings emphasized, are displayed in Table 3.

Of the 18 items, all but one, "percentage of networked PCs," correctly loaded in the predefined constructs. Removing this item completely from the scale did not significantly change the model; therefore, it was dropped from the analysis. Overall, strong loadings indicate that discriminant and convergent validity are adequate for this study. To test for the effects of multicollinearity, variance inflation factor (VIF) and collinearity diagnostics were performed (Howell, 1992). The calculated VIFs (between 1.002 and 1.139) indicated no threat of multicollinearity and the calculated tolerance factors for each of the variables (all greater than .9) further indicate that the presence of any particular variable in the model does not influence the effects of the other variables.

Table 2: Independent and dependent variables

Variable Observed	Measure	Mean	S.D.	Alpha
Competition	Single Item	3.97	1.04	
IS Structure	5 items on responsibility of intranet development	3.64	0.61	0.65
IT Infrastructure	6 items on IT flexibility, portability, connectivity	3.36	0.84	0.63
Organizational Size	0-7 based on number of people in organization	4.50	2.09	
Organizational Structure	2 items on centralization of decision making	3.55	1.04	0.81
Top Management Support	4 items of CEO support for intranet	3.25	1.17	0.92
Infusion	1-3 based on low, medium, or high levels	1.65	0.59	

An ordered probit analysis was conducted to test the research model for this study. Ordered probit is used to estimate the relationships between an ordinal dependent variable and a set of independent variables (Greene 1997). The infusion variable being measured in this study is categorical and ordered; that is, respondents reported intranet infusion levels of low, medium, and high for their organizations. As there is a definite sequence to the levels of intranet infusion, ordered probit analysis provides an appropriate means for exploiting the ordering information[1]. The variable "howlong" was entered into the model along with the six independent variables in the model to control for the effects of intranet maturity in the model. The ordered probit results are presented in Table 4.

Overall, the research model for infusion is statistically significant, as indicated by the chi-squared value of 57.824 ($p < .0001$) and is therefore suitable for prediction. Significant relationships were found for top management support ($b = 0.1357$; $p < .05$), IT infrastructure ($b = 0.1777$; $p < .10$), organizational size ($b = -0.0961$; $p < .01$), competition ($b = 0.2000$; $p < .01$), and how long ($b = 0.3179$; $p < .001$).

Table 5 presents the marginal effects of each independent variable on the each of the infusion levels. The marginal effects for each variable are measured at the means of the independent variables and are the partial derivatives of the probability of each level of infusion with respect to each of the independent variables.

In the ordered probit model it is possible for the marginal effect to change sign as well as magnitude as the values of the independent variables change. Table 5 provides a description of the effects on the varying levels of infusion as the values for the independent variables increase. For example, as top management support increases, the probability of an infusion level of 1 decreases by approximately 12%. Similarly, increasing top management support increases the likelihood of an infusion level of 2 by 3% and would increase the likelihood of an infusion level 3 by roughly 2%. The effects of increased top management support change in direction and magnitude for each level of infusion. This corroborates with the first hypothesis (H1),

Table 3: Rotated component matrix

	1	2	3	4
Top Management Support				
Critical to CEO	**0.915**			
CEO support for integration	**0.876**			
CEO considers strategic investment	**0.889**			
CEO support for use	**0.833**			
IT Infrastructure				
Complexity of current applic. s/w		**0.426**		
Shareable IS-based corporate data		**0.734**		
Elec. communication btw offices		**0.485**		
Percent of networked PCs *		0.267		
Data sharing in major systems		**0.592**		
Current stds. support future compat.		**0.452**		
Applic. s/w transportability		**0.694**		
Organizational Structure				
Employee partic. in decision making			**0.600**	
Decision making top-down (reverse)			**0.716**	
IS Structure				
Resp. for choosing intranet applic s/w				**0.722**
Resp. for intranet applic. dev't				**0.607**
Resp. for intranet hardware				**0.609**
Resp. for intranet software				**0.686**
Resp. for updating content				**0.531**

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax With Kaiser Normalization.
Rotation converged in 9 iterations.
* item dropped from analysis

which proposed increasing top management support would be positively associated with higher infusion levels of intranet applications. Similar results are demonstrated for competition and for IT infrastructure flexibility, supporting hypotheses (H4) and (H5). Interestingly, the marginal effects for organizational size suggest that as the organizational size increases, the probability of infusion levels greater than 1 decreases. These results are the direct opposite of what was hypothesized in (H3). A discussion of the results follows.

Table 4: Ordered probit results

Variable	Coefficient	Significance
Constant	-1.342	0.054
How Long	0.318	0.000****
Top Mgmt Support	0.136	0.041**
Organization Structure	-0.085	0.270
Organization Size	-0.096	0.008***
Competition	0.200	0.006***
IT Infrastructure	0.178	0.094*
IS Structure	-0.049	0.672

**** p < .001; *** p < .01; ** p < .05; * p < .10
Chi-square: 57.824; df: 7; significance: .0000

Table 5: Marginal effects of independent variables on infusion levels

Variable	Infusion = 1	Infusion = 2	Infusion = 3
Constant	0.5233	-0.3415	-0.1818
How Long	-0.124	0.0809	0.0431
Top Mgmt Support	-0.0529	0.0345	0.0184
Organization Structure	0.0331	-0.0216	-0.0115
Organization Size	0.0375	-0.0245	-0.013
Competition	-0.078	0.0509	0.0271
IT Infrastructure	-0.0693	0.0452	0.0241
IS Structure	0.0191	-0.0124	-0.0066

DISCUSSION

Support was found for three of the six hypotheses, namely, the positive relationships of top management support, IT infrastructure, and competition with intranet infusion. In support of H1, the findings suggest that top management support is essential for intranet technology to be exploited and used to its fullest potential. This is not surprising since the majority of IS research concerning top management support and IS implementations consistently reports similar results. There was no support for H2, indicating that a centralized or decentralized management structure does not appear to influence the degree to which intranets are being infused in organizations. While it was anticipated that a decentralized organization would perceive greater benefits from an intranet used to its fullest potential, the findings in this study suggest that the structure is not related to infusion.

The direction of the significant relationship between organizational size and intranet infusion was negative, contrary to the expectations of H3. It is possible that smaller organizations have higher levels of intranet infusion because of the perceived need to be more competitive (Aldrich & Auster, 1986; Katz, 1970). It has been suggested that small organizations are more likely to act aggressively and initiate competitive actions. Similarly, larger firms have been found to behave more complacently when faced with competition (Hannan & Freeman, 1984) and may be slower to implement a more complex technological innovation. Another explanation may be that large organizations have a higher degree of structural complexity and bureaucracy (Mintzberg, 1979) and unwieldy information processing systems (Galbraith, 1977) that could constrain the speed of implementing more complex technological innovations. The relationship between organizational size and intranet infusion is an area that warrants further research.

The findings support H4, suggesting that organizations in more competitive environments are likely to deploy intranets more aggressively than organizations in less competitive environments. Prior studies have concluded that when organizations are facing market uncertainty, they seek new innovations to improve their competitive positions. The present findings suggest that management views the infusion of intranet technology with business processes as a competitive tool since it greatly increases the availability of interactive organizational data. Conversely, low intranet infusion within organizations in uncertain market environments could be viewed as a disadvantage over time.

There is modest support for Hypothesis 5 (H5) to suggest that an organization with a flexible existing IT infrastructure is more likely to experience greater intranet infusion than an organization whose IT infrastructure is less flexible. While there is little doubt that a more flexible IT architecture will ease the development of collaborative and interactive applications, our findings suggest that other organizational factors such as top management support, competition, and the size of the organization play more influential roles in their association with intranet infusion. The process of IT infusion, "using IT to its fullest potential," involves the integration of business processes with the technology to improve work flows. As antecedents to intranet infusion, it makes sense that factors such as these would be more highly significant since intranet technology is perceived by many as a vehicle that can improve the effectiveness of an organization.

There was no support for the proposed significant relationship between IS structure and intranet infusion (H6). IS structure was examined to determine where the locus of control for intranet application development and maintenance was. As was anticipated, however, respondents indicated the IS department was primarily responsible for intranet hardware and software and the responsibility for maintaining and updating intranet applications was a combined effort between the IS department and the end-user departments. This is consistent with reports in the popular press that end users are primarily responsible for building their own intranet applications. The lack of support for this hypothesis may be explained by the fact that intranets are a relatively new information technology being implemented in environments where the use of information technology is not necessarily new. It is possible that organizations that have experienced successful IT infusion with their existing IS structure, whether it is of the hybrid form or not, will experience similar results with the implementation of intranet technology.

CONCLUSION

The trend among organizations is to move from proprietary system architectures to open systems architectures. Intranets represent a backbone for open systems because they provide the communication linkages for computer-based applications and information throughout an organization. Furthermore, intranets are fast becoming the enabling infrastructure for supporting business applications that solve business problems and/or create business opportunities. The present investigation reports factors that can significantly affect the infusion of this technology. Research that examines the implementation of technological innovations affecting the entire organizational computing structure is relatively new. Chau and Tam (1997) provided one of the first studies to examine factors affecting the decision to adopt open systems technology. They concluded that perceived barriers such as complexity and satisfaction with existing systems were negatively related to the adoption decisions and that competition and IT infrastructure were not statistically related. The present findings broaden research in this area by suggesting that the factors that affect the implementation of an organization-wide IT are different in significance from those that affect the adoption decision.

The results of this study have practical implications. First, it is evident that top management support is positively associated with high infusion levels of intranet technology. Hence the lack of senior-level management involvement on the organization-wide implementation of intranets would most likely have a negative impact on the use of the technology to its fullest potential.

Secondly, greater levels of infusion for an organization-wide information technology are likely to produce increased interconnectedness of work flows. Likewise, higher levels of intranet infusion should produce greater organizational benefits. For example, Federal Express's intranet implementation represents a deployment that has been highly infused into organizational work flows with full support from upper management. As a result, their intranet has enabled 2,200 locations worldwide to be connected, allowing customer catalog displays and order acceptance, fulfillment, and shipment to be managed via the corporate intranet. Federal Express has realized a substantial cost savings as well as improved customer satisfaction (Senn, 1998).

A surprise finding was the highly significant negative relationship between organizational size and intranet infusion. This was contrary to our expectations that larger firms would have the resources and the perceived need to implement higher level intranet applications and has important practical relevance. Our empirical evidence suggests that smaller organizations are deploying intranets more aggressively than larger organizations. The potential implication is that over time, smaller organizations may present stronger competition to large organizations as a result of their effective use of organization-wide information technology resources.

Lastly, our findings validate the popular press claims that intranets are rapidly being deployed in organizations of all types and sizes. Our findings support the notion that managers view the deployment of intranets as being critical to organizational success. The high percentage of organizations that have intranets suggests that additional research should focus on the continued advancement and infusion of the corporate intranet infrastructure. In particular, opportunities for further research include investigating the impact of organizational factors on the maturation process of the corporate intranet as well as its continued impact on organizational effectiveness.

ENDNOTE

1 The ordered probit model estimates $Z = X'\beta$, where x is a vector of independent variables and β the vector of coefficients. The ordered probit Z-scores correspond to standard normal deviates for each of the possible outcomes. If, for example, Z for level 2 infusion is estimated to be 1.645, the probability of level 2 infusion is 95%, the area of the normal curve falling to the left of 1.645.

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Chapter XIV

Dynamics of Information in Disseminating Academic Research in the New Media: A Case Study

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Much academic research on information technology (IT), systems (IS), and management (IM) has been branded by practitioners in business as unusable, irrelevant, and unreadable. Consequently, it is highly unlikely that conventional outlets for such work, e.g., scholarly journals and conference proceedings, can receive significant real-world exposure. By reversing the push-pull dynamics of information dissemination and retrieval in the new media, alternative approaches are emerging. This article presents the history of a case in point with data recorded over a period of 15 months. It is shown that the Internet in general and the World Wide Web in particular will be significant resources in bridging the gap between practice and relevant research.

INTRODUCTION

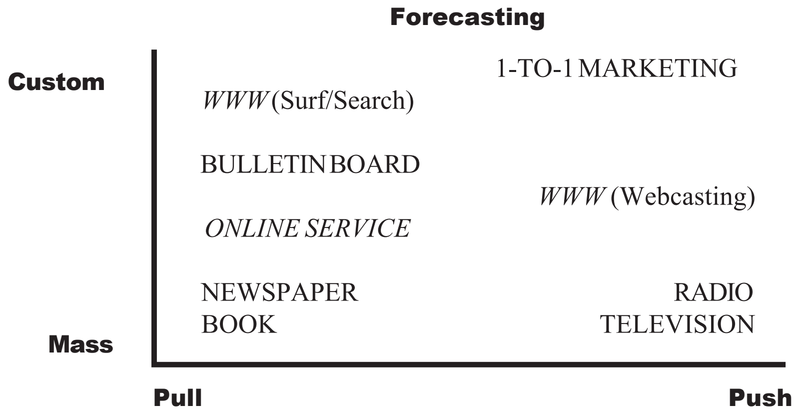
Since the conventional medium for the dissemination of academic research is that of the printed journal, it is appropriate to adopt the newsprint industry's terminology of the New Media for Internet-based communication. As the World Wide Web (WWW or Web for short) has emerged as the increasingly dominant application of the Internet to publish and browse information, we assume it to be the primary platform for the New Media. Given the perception among practitioners of printed journals as mostly irrelevant academic research, the natural question is whether the New Media can make any difference. For the answer, we need to examine what initiatives academics have taken on this front.

There is indeed a growing body of literature on scholarly electronic publications (see Bailey, 1997, for a bibliography.) In the IT-research area, there were discussions of a global community of scholars (Watson, 1994), electronic journals as legitimate media (Kling & Covi, 1995), and barriers–motivational, institutional, technical, and philosophical–to adoption (Ives, 1996). Yet, the focus has remained by-and-large "intramural," in the sense of exploring the technical possibilities within the confines of well-set academic values and priorities among scholars. Even in cases that go beyond transplanting old practices to the New Media, implying transformation of processes such as peer review and collaboration, there is little effort in breaking the mold of prevalent academic culture. In brief, the academic trend in deploying the New Media can only lead to the same kind of knowledge base that is of little use to practitioners (Harrison & Stephen, 1996).

This prompted an examination of the underlying issue of information dissemination and retrieval. With the New Media, this has become known as push versus pull (Cortese, 1997). In Ho (1999) a two-dimensional framework is proposed to capture such dynamics of information. Horizontally, the relative characterization of how information is disseminated and acquired is displayed. Note that to the extent that information is being made available for public consumption, there is always an element of push in the sense of broadcasting, whether it is in print, airwaves, or electronic signals. Without any attempt at formal definitions, it is important to have some guiding principle to distinguish push from pull. A simple one is in the form of a question: "Can you look it up at your own leisure?" If so, then it is pull. This is certainly the case with books in a library or newspapers on a coffee table, but not so with the real-time broadcast of radio or television programs. The vertical axis indicates whether the content of the medium is primarily designed for mass consumption, or customizable to individual interests. The question to ask here is "To what extent do you see only what you are looking for?" In this sense, the distinguishing emphasis is put on how an individual is guided to information of interest, rather than the selectiveness of the overall material. For example, a typical book is a line by line presentation (linear text) designed by the author. Much as any reader can skip around the pages, the layout is the same for everyone and primarily meant to be followed cover to cover. By contrast, a dictionary, while providing the same overall content to every user, is specifically designed to help find only what one is looking for.

Within this framework, both conventional and emerging media can be characterized (see Figure 1). Books and newspapers are highly mass-pull while radio and television are highly mass-push. Bulletin boards, especially those with classified and want ads, sit higher on the custom scale (the same goes for special sections of newspapers for this purpose). So-called 1-to-1 marketing (Peppers & Rogers, 1996), in which individual purchasing behavior is culled from massive customer databases and used to target advertising campaigns, can be considered highly custom-push. Three Internet-based media are shown in italics in Figure 1. Online services, in the

Figure 1: Schematic of information dynamics



role as content providers, are somewhat more custom-pull then newspapers. The World Wide Web, as a repository of hyperlinked multimedia, is much higher in the same column. Webcasting (Business Week, 1997), which has gained much attention recently, is push and not much higher than online services on the custom scale. Focused broadcasting (Ho, 1999, 2001) is a balanced approach to match classified and want ads in cyberspace.

Actually, any mode of information exchange is a mix of push and pull (DeJesus, 1997). While television broadcasting is considered a prime example of push, the viewer must turn it on (pull) and off. Similarly, while a book sitting on a shelf may suggest pure pull, the process of publishing is push. This last analogy is particularly apt for considering alternative outlets for academic research in the New Media. With the conventional channel of scholarly journals, the perceived quality standards as reflected in the rigor in peer reviews and stringent acceptance rates serve to push its content. Pulling on the part of the reader is more in the nature of "Let's see what is in this issue of a trusted resource" than "Let's see what is out there that I need." An alternative of reversing the relative emphasis on push and pull now emerges. This article presents the history of a case in point with data recorded over a period of 15 months. It is shown that the Internet in general and the World Wide Web in particular will be significant resources in bridging the gap between practice and relevant research. First, we discuss the reality of such a gap.

THE WIDENING GAP BETWEEN BUSINESS PRACTICE AND ACADEMIC RESEARCH

The relevance and applicability of academic research conducted in business schools have long been questioned. In their 1984 *Harvard Business Review* article, Behrman and Levin concluded that:

> For the most part ... the research in business administration during the past 20 years would fail any reasonable test of applicability or relevance to consequential management problems or policy issues.

In the comprehensive review of management education and development, Porter and McKibbin (1988) further distinguished between the relevance of such research and the import of the reported findings. Based on extensive interview and survey data, they observed that the business community knows relatively little about the research programs and their findings. Apart from the routine distribution of a reprint series to supposedly interested parties,

> Most business school professors are purposely aiming their research reports toward their academic brethren and ... do not care whether such publications are comprehensible to practicing managers or not.

The result is a pervasive lack of "corporate knowledge" of business school research. This communication gap further deprives academic researchers of the impetus and critical feedback from the business community which may help increase the impact of their work.

Apparently, the situation has not improved significantly since. In spring 1995 the Board of Directors of the American Assembly of Collegiate Schools of Business (AACSB, which has since been renamed The International Association for Management Education) appointed a task force to look at the leadership and development needs of business school faculty and to determine how best to meet those needs. In the report (Urban, 1996) released in April 1996, the primary problem identified was that faculty skills are not aligned with the rapidly changing needs of business, resulting in the widening of the gap between practice and academic research and teaching.

While the above critiques applied to academic research in business in general, the state of affairs specific to the information-related fields: information technology (IT), information systems (IS), and information management (IM) is no exception. To quote Tom Davenport (1997), who is well-established both in practice and in academe:

> The state of IT-oriented research is downright dismal. ... Much IT-oriented research is neither comprehensible nor practical. ...The topics researched are less than au courant. ... The journals in which academic IT research is published are rarely read by practitioners. ...They are often unfathomable, even to other academics. ...[The] publications contain pseudoscientific jargon, arcane statistical techniques and slavish footnoting.

Similar opinion has echoed in the practitioner-oriented press (Alter, 1997):

> Too much academic research on IS is unusable, irrelevant and unreadable. Most professors seem content to write about jargon-filled frameworks, vague theories and marginalia rather than help solve today's nagging problems. ... Junior faculty members who produce good research are afraid to share it with the press. If they do, they may ruin their chances at publishing it in academic journals and wreck their chances at tenure.

The causes for such criticism are obviously deep-rooted and it will be naive to contemplate any quick fix. Instead, we address one consequence of this apparently pervasive public perception. Since the connotation of academic research has become "esoteric and irrelevant" rather than "rigorous and useful," one may speculate that traditional outlets of scholarly work, such as journals and conference proceedings (Hosapple, Johnson, Manalyan & Tanner, 1994), cannot be effective media to reach a potentially broad audience for relevant results. The question is then: if a professor does come up with research that is relevant, are there alternatives to the established outlets to disseminate such information? We present a case in point and document its development over a period of 15 months. It has implications in establishing the Internet in general and the World Wide Web in particular as significant resources in bridging the gap between practice and relevant research.

METHODOLOGY

To realize this alternative, we designed the following experiment. Use the timely results of a research project that has obvious relevance to contemporary business interests. Put up a summary page on the Web, including an electronic form for requesting the full report. The process of locating and downloading the report constitutes the pull aspect of this approach. For the push aspect, launch an initial publicity campaign for the research in the business and IT-related press. Record and study the demographics and source of referral of respondents as an indication of the potential of the New Media as an outlet for research results. Finally, identify specific linkages within the New Media as effective elements to bridge the gap between practice and research.

THE CASE OF WWW1000

Currently, the topic of electronic commerce is relevant and timely as businesses large and small are scurrying to stake a presence in this new frontier. Our initiative was based on the following observation. While commercial applications of the Internet, particularly in the form of business sites on the World Wide Web proliferate, on-line business is still relatively insignificant. Apart from the well-known difficulties with bandwidth and security, technical issues that can no doubt be resolved eventually, there is the more probing question of what value is being created on the Web. Certainly, one cannot expect real progress if it is simply the digital replacement of conventional channels such as newspaper ads, TV commercials, phones, and fax. In spring 1996, the author proposed a framework to evaluate Web sites from a customer's perspective of value added. Representative samples from 40 industries, totaling 1,000 sites, were evaluated to give a snapshot of where we stood in mid-1996.

The framework has the two dimensions of "purpose" and "value" as illustrated in the 4x3 matrix in Appendix A along with examples of Web site features or functions that fit each of the purpose-value combinations. A sample of 25 Web sites was randomly selected from each of the the 40 industries listed in Appendix B.

Each site was explored in sufficient detail so that all its value-adding features were identified and classified using the above framework. The percentage of sites having features in each purpose-value category was recorded. The results were tabulated, analyzed, and discussed. The evaluation approach as well as the results were summarized in plain English on a Web page which included an electronic form for the interested reader to request a full report. The reader was asked to supply his or her name, title/position/occupation, company/organization, e-mail address, and where he or she found out about the summary page for the study. The full report, which contained results tabulated by industry and brief narrative accounts of each sample and the common and special features encountered, was set up as a downloadable PDF (portable document format) file. A condition of use was included on the front page asking readers who would like to refer others to this work to do so with the summary Web page, rather than passing along the full report directly. This was to help us track as many readers as possible. On receipt of a request, the supplied data was logged and an e-mail was sent to the reader with instructions to access the full report. Apart from the URL of the PDF file, information on where to download the free Acrobat reader software from Adobe Systems was provided for readers who were not yet set up to process such files.

CHRONOLOGY OF EVENTS

Between June 2 and June 5, 1996, the following informal "press release" was sent via e-mail to 47 editors of 40 business and IT-related publications (Appendix C) with significant practitioner readership.

Evaluating the World Wide Web: A Study of 1000 Commercial Sites

Dear Editor,

The results of our research project "Evaluating the World Wide Web: A Study of 1000 Commercial Sites" may be of interest to your readers. A summary page is at http://www.uic.edu/~jimho/www1000.html.

Jim Ho
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The study was featured as the "Web Site of the Week" in *InformationWeek* on June 10; as a new and notable "Hot Site" by *USA Today* on June 11; and as the "Pick of the Web" in *Computer Week* of Australia on June 14. It was also noted in the *Marketing & Design Daily* and the *Newstips Electronic Editorial Bulletin* in the same week. In the following week, it began to appear as a reference resource on the intranets of several major corporations, including Ameritech, Dupont, Unisys, and Xerox. Shortly after, it was listed in the Electronic Commerce in A Business Researcher's Interest section.

From the leads supplied by readers requesting the full report, references to the study were tracked over a period of 15 months from June 1996 through August 1997. Links to the summary page were found on diverse types of Web sites: Internet-related ventures such as JetForm, NetRevenue, Novaquest, Internet Plus (Australia), Bureau voor On-line Marketing (Netherlands), Noesis (Sweden), and 4thMedia (UK); public forums such as The Netpreneur Exchange, the Potomac KnowledgeWay Project, the Atlanta Electronic Commerce Forum, and Richard Seltzer's Chat Group; government projects such as CORDIS (European Community R&D Information System), and the New Zealand Government Web Support Group; course pages at universities such as Boston University, Northeastern University, Université Laval (Canada), and City University of London (UK); and professional interest-groups such as GISE (Global IS Education), Internet Bulletin for CPAs, and IOMA (Institute of Management and Administration). In the print media, references were found in industry research reports, articles and books such as CSC (1996), CTR (1997), Hayes (1997), and Thackara (1997).

Meanwhile, progress was made in our original project to include the evaluation and comparison of commercial Web sites worldwide. A comparative study with an additional 800 sites from 20 industries in Australia, England, France, Germany, Hong Kong, Italy, Singapore, and Taiwan was completed. The report (Ho, 1997) was published in the scholarly electronic *Journal of Computer Mediated Communication* (JCMC) in June 1997. From then through August 1997, readers requesting a full report received an e-mail pointing them to the JCMC article. At the conclusion of our tracking project on August 31, the electronic form on the summary page was removed. A direct link to the published article is now provided.

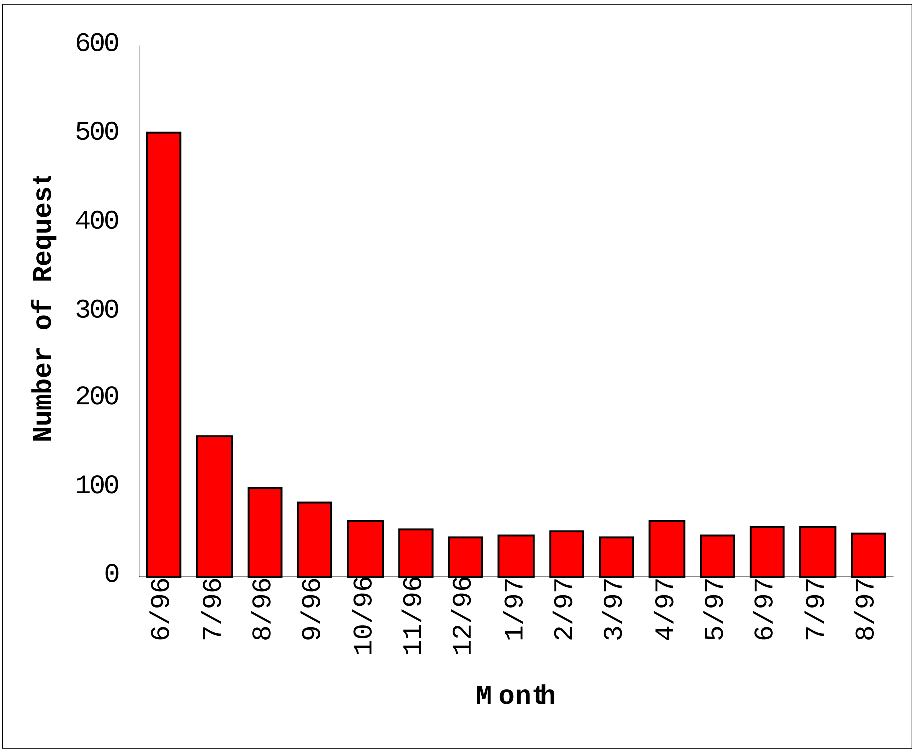
THE RESPONDENTS

Over the 15 months, a counter embedded in the summary Web page registered 4,503 visits. A total of 1,417 requests transmitted through the electronic form were received. The distribution of the number of requests by month is charted in Figure 2. Apart from the U.S., which accounted for 1,044 requests, the remaining 373 originated from 45 countries. We use the term "country" loosely and generically here as the geographic designations actually included political entities such as special administrative region and principality.

They are listed alphabetically with their two-letter code (ISO 3166) and the number of requests:

Austria (AT: 1), Australia (AU: 42), Belgium (BE: 8), Brazil (BR: 8), Canada (CA: 43), Chile (CL: 1), China (CN: 2), Costa Rica (CR: 1), Denmark (DK: 4),

Figure 2: Number of requests by month



England (UK: 51), Finland (FI: 8), France (FR: 12), Germany (DE: 9), Greece (GR: 5), Hong Kong (HK: 13), India (IN:2), Indonesia (ID: 1), Ireland (IE: 5), Israel (IL: 1), Italy (IT: 21), Jamaica (JM: 1), Japan (JP: 2), Korea (KR: 18), Malaysia (MY: 5), Malta (MT: 1), Monaco (MC: 1), Netherlands (NL: 21), New Zealand (NZ: 22), Nigeria (NI: 1), Norway (NO: 3), Philippines (PH: 1), Poland (PL: 4), Portugal (PT: 3), Russia (RU: 2), Spain (ES: 6), Singapore (SG: 13), South Africa (ZA: 6), Sweden (SE: 11), Switzerland (CH: 4), Taiwan (TW: 5), Thailand (TH: 1), Trinidad (TT: 1), Ukraine (UA: 1), Uruguay (UY: 1), and Venezuela (VE: 1).

From the entries of job title, position, or occupation, the following catagories were identified.

Senior Executives–CEO, President, Vice President (VP), Managing Director (MD), CFO, CIO, Owner, Chairman, Dean.

Managers–Manager, Director, Supervisor, Head, Chief of Department, Division, or Program.

Staff–Member of technical or administration staff, analyst, consultant, research associates.

Self-Employed–Only as specifically indicated.

Attorney/CPA–Only as specifically indicated.

Faculty–Lecturer, Professor (all ranks).

Student–Undergraduate, Graduate, MBA, Ph.D. Candidate.

The distribution of occupations for the 1,417 respondents is charted in Figure 3.

Figure 3: Distribution of occupations (Total = 1,417)

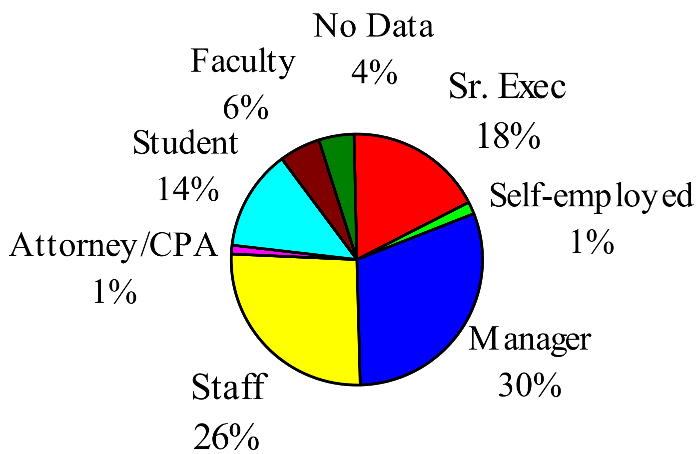
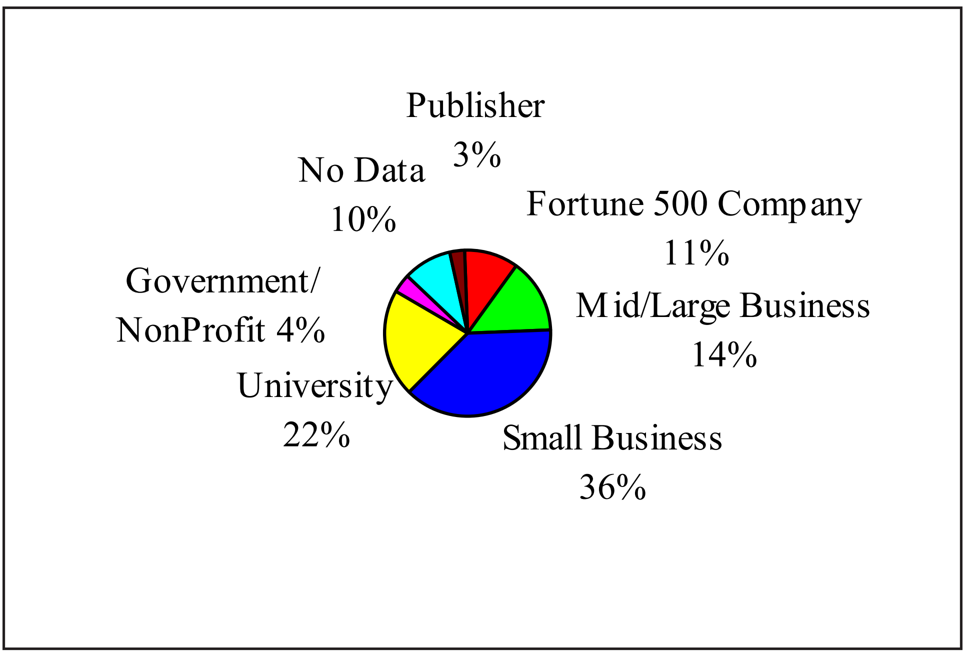


Figure 4: Distribution of affiliations (Total = 1,417)



From the entries of company or organization or affiliation, the following categories of affiliation were identified.

Fortune 500 Company: On either the 1996 US list or Global list.
Mid/Large Business: Recognizable names and major privately held firms.
Small Business: Mostly Internet-related upstarts.
Publisher: Periodicals and books.
Government/Nonprofit University

The distribution of affiliations for the 1417 respondents is charted in Figure 4. To see which positions from what kind of organization we attracted, note that faculty and students were affiliated with universities; the self-employed had no affiliation; and attorneys and CPAs were few in number. It remains to find out where the senior executives, managers, and staff were from. The breakdown is cross-tabulated in Table 1.

THE SOURCES OF REFERENCE

From the myriad sources quoted, six major ones were identified:

InformationWeek: Summary page as "Web Site of the Week" on June 10, 1996.
USA Today: Summary page as new and notable "Hot Site" on June 11, 1996.
Word of Mouth: Mostly colleagues, coworkers, friends, classmates.
BRINT: Y. Malhotra's A Business Researcher's Interest reference site.
Search Engine: Mostly searches on e-commerce, online marketing, etc.
Web Links: All other links, including random surfing, and printed references to summary page.

The growth in the number of requests by source of reference is illustrated in the cumulative chart in Figure 5.

Table 1: Distribution of three occupations by affiliation

	Sr. Exec	Manager	Staff
Fortune 500 Company	2%	15%	20%
Mid/Large Business	10%	24%	18%
Small Business	80%	43%	33%
Government/NonProfit	3%	5%	7%
University	0%	5%	10%
Publisher	3%	4%	5%
No Data	2%	5%	7%
Total(100%)=	**256**	**421**	**374**

To see where readers of various occupations found out about the study, we cross-tabulate the significant entries in Table 2. Similarly, the breakdown for requests from the U.S. and abroad is shown in Table 3.

Figure 5: Cumulative number of requests by source of reference

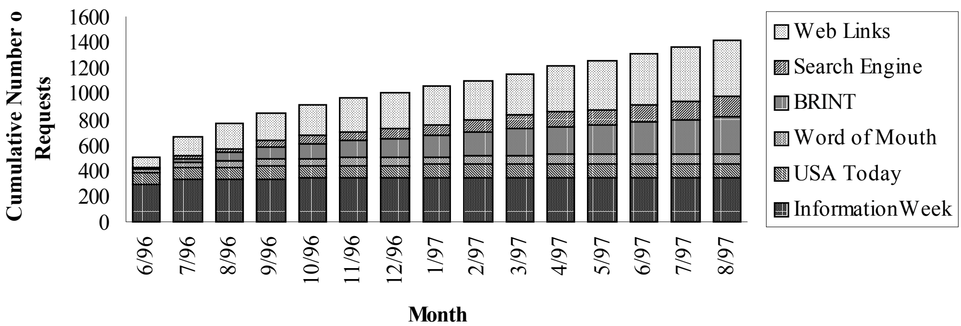


Table 2: Distribution of five occupations by source of reference

	Sr. Exec	Manager	Staff	Student	Faculty
InformationWeek	29%	34%	27%	4%	9%
USA Today	9%	7%	7%	3%	6%
BRINT	14%	18%	20%	41%	20%
Search Engine	8%	9%	11%	18%	11%
Word of Mouth	5%	6%	6%	6%	11%
Web Surfing	6%	4%	7%	4%	8%
Web Links	24%	17%	16%	15%	20%
No Data	5%	5%	6%	9%	14%
Total(100%)=	**256**	**421**	**374**	**193**	**79**

Table 3: Distribution of domestic and foreign requests by source of reference

	US	Foreign
InformationWeek	31%	5%
USA Today	8%	3%
BRINT	16%	33%
Search Engine	9%	17%
Word of Mouth	6%	7%
Web Surfing	4%	4%
Web Links	19%	20%
No Data	7%	11%
Total(100%)=	**1044**	**373**

OBSERVATIONS

As the purpose of our project is to test the potential of an alternative to the conventional push-pull balance of disseminating research results, we need to first comment on the data that was not obtained. Of the 4,503 visits to the summary page, 1,417 resulted in a request for the full report. We can interpret the latter as the number of people who were interested enough to go through the process. The rest, who did not, must still be somewhat interested initially. However, their reason not to follow through could be manifold:

i) From the summary, they realized it was not what they were looking for;
ii) They were content with the information provided in the summary;
iii) They were wary about giving out personal information; or
iv) They did not have an e-mail address.

In any case, we were not able to track this segment and learn about the demographics and source of reference.

Those who did respond were quite forthcoming. With a few exceptions, we sensed that omission of data was more inadvertent than intentional. Remarkably, the choice of words did matter. Initially, we used the term “affiliation” to subsume company, school, organization, etc. It turned out that many readers, mostly from non-English speaking countries did not understand or misunderstood. After noticing a number of defensive “None” and puzzled “?” we changed it to “company/organization.” Even the question of “Where did you find out about this summary page?” drew a few incredulous “On the Internet, of course!”

We did not detect any case of gross misrepresentation (i.e., obvious fake.) As one indication, 99% of the return e-mails pointing to the full report went through. However, there were quite a few cases of undeliverable mail resulting from either typographical errors or logical confusion. Every effort was made to guess at the correction. For example, someone with an @ibm.net address (as a subscriber to the company’s network service) might give it as @ibm.com (typically used for employees of the company.)

We terminated the tracking project after 15 months for the following reason. Given that the data and the results were of a timely nature, we expected a transient phase for the requests to build up, a peak, and then a decline. It turned out that both the rapid growth and peaking all took place within the first month (June 1996.) However, it was not clear whether the reference linkages would produce a steady state of requests or total decay. After the 3 to 5-month transient phase, the subsequent 10 to 12-month period did indicate a steady state with an average of 52 requests per month.

Although one third of the 46 countries that we heard from generated only a single request, the global reach of the New Media is still impressive. The distribution of the number of requests by country provides the basis for further investigation into how well and willing various countries are connected and communicating with the rest of the world. The factors are both technological and cultural. For example, the development and deployment of the Internet infrastructure in Japan must be at least as advanced as in Korea. Yet, we received only 2 responses from Japan compared to 18 from Korea. This may be an indication that Japan has a much more "close-knit" cyberculture than Korea.

Professionals (senior executives, managers, staff, attorneys, CPAs, self-employed) accounted for 76% of the requests, compared to 20% from academics (students and faculty.) Since almost all the reference sources stated clearly that this was academic research produced by a professor at a university, we have shown that at least the topic of the study managed to overcome any alienation on the part of the practitioners. A large variety of businesses were represented, with 154 requests from U.S.-based Fortune 500 or foreign Fortune Global 500 companies, 195 from midsize to large firms including advertising, banking, accounting, consulting, realty, and privately held companies, and 524 from small businesses, many of which being Internet-related upstarts. As the distinction between the last two categories was not well-defined, we subjectively classified all recognizable names or entities (e.g. banks, public utilities, hospitals) as mid/large. Note that these counts were for requests and not for distinct companies. Most multiple requests came from two dozen or so of the larger firms and typically from different divisions or locations.

A total of 309 requests originated from 247 academic institutions: 193 from students, 79 from faculty, and 37 from staff and administrators. The relatively low number for faculty may be explained by some combination of the following factors:

i) Not many professors rely on the sources referencing our study.
ii) Not many professors are interested in business applications of the Web.
iii) Professors do not consider the type of study we conducted of academic interest.

Given that the thrust of our effort to publicize the report was practitioner-oriented, the first factor was likely to be predominant. This is perhaps evidence of the flip side of the gap between academics and practice: professors tend not to use business sources, just as practitioners tend not to read scholarly journals. As to the other two factors, academic interest in the published report can in principle be traced (to the extent of a reader's Internet domain category) in the Web site statistics for the electronic journal *JCMC*.

Next, we consider the effects of different reference sources. From the cumulative distribution of requests over time displayed in Figure 5, it is clear that the major initial impetus came from a very compact piece of publicity in *InformationWeek*, a periodical for business and technology managers, under its "Web Site of the Week" rubric (Scott, 1996):

> A University of Illinois project called "Evaluating the World Wide Web: A Study of 1000 Commercial Sites," may interest corporate Webmasters and marketers. It's at http://www.uic.edu/ ~jimho/.

This accounted for 291 of the 503 requests received in the first month. However, as typical of the news media, its effect was transitory. The referrals grew to 324 in the second month, 331 in the third, and remained at 347 by the end of the project. The situation was similar with the exposure in the online version of the national newspaper *USA Today* (Meddis, 1996):

> Professor James K. Ho of the University of Illinois at Chicago studied 1,000 commercial Web sites to see how a potential customer might feel about their online value. Among the findings: Interactive transactions are still pretty primitive. Good reading for anyone interested in making serious money on the Web.

This generated 93 requests in the first month, and only 8 more since. Note also from Table 2 that, as a resource, *USA Today* was quite evenly distributed across occupations, while *InformationWeek* was concentrated on the business professionals.

The sources that sustained the steady growth in requests are all some form of Web links. The most significant of these is Yogesh Malhotra's "@BRINT: A Business Researchers's Interest" (www.brint.com), a so-called "meta-site" of references that has been highly acclaimed by the business and technology press worldwide. It is a delicate balancing act between being comprehensive and being selective. Many reference lists start out being useful until indiscriminate growth renders them unwieldy and strips them of value-adding information. On the other extreme, scholarly journals strive to be selective and forego timeliness and breadth of scope. What efforts such as @BRINT are accomplishing with the cost effectiveness of Web technology is to provide a middle ground through discerning editorial judgment. Their value is evidenced in their increasing use, especially by students (accounting for 41% of requests in that category in our case) and international users (33% of category.) The following synopsis of our work is listed in the Electronic Commerce section of @BRINT:

> A review of 2,000 commercial Web sites from four continents affirms the critique that they are mostly variations and adaptations of conventional marketing and broadcasting channels. Few of them demonstrate any clear-cut strategies reflecting well-articulated vision and commitment of top management.

Starting with the second month, @BRINT produced an average of 21 requests per month, with a maximum of 36, a minimum of 12, and a standard deviation of 7. The overall total was 289, which was remarkably close to the initial spur by *InformationWeek*.

Note that there is a high concentration of managers referred by InformationWeek, and students by @BRINT. Also, source of reference differs for US and foreign requests. While *InformationWeek* and *USA Today* are primarily domestic references, @BRINT is a major resource for international readers.

The sources labeled Web links in Figure 5 included all citations of the study on Web pages other than those mentioned above, leading to a total of 440 requests. Typical examples are already described in the Chronology of Events section. It should be pointed out that many such links may reflect a secondary effect of the major sources, as when a manager included our study as a business resource in the company's Web site after learning about it from, say, *InformationWeek*. Even less distinctive were those referrals (numbering 156) attributed to search engines. We do not know whether such searches led the reader first to some other site (the more likely scenario) or directly to our study. In any case, we do know that, collectively, the Web-based sources provided a steady stream of requests over time.

DISCUSSION

Judging from the level of interest and the diversity of responses, our experiment to disseminate research results in the New Media appeared to be a success. The main lesson learned can best be explained in the context of the balance in the push-pull dynamics of information exchange. Conventional journal publication can be viewed as well-established and organized push efforts, with the prestige and recognition of the journal being the driving force. An article in a journal is essentially broadcast to the journal's intended audience. Previously, it would be relatively difficult to reach potential readers otherwise. With the New Media, alternative approaches shifting the push-pull balance become feasible. A research report set up on the Web can in principle be browsed by anyone. From this totally passive mode of pull, one may consider incremental adjustments toward push. This was illustrated in the present case by the various forms of publicity the report received:

i) automatic indexing by search engines;
ii) submission to search engines for indexing;
iii) solicited publicity in the print media;
iv) unsolicited publicity in the print media;
v) unsolicited links on the Web;
vi) submission to meta-sites for linking.

A generic process to "publish" research results in the New Media is then:

I. Set up the report on the Web;
II. Select a mix of push options;
III. Track publicity and links generated.
IV. Track response and readership (optional).

Note that the unsolicited items within the mix of push options are not under the author's control. These are akin to literature citations in conventional publishing. The relative success in generating links and the eventual effectiveness of attracting readers will depend on the nature and topic of the underlying research work. Our case being on a topic concerning the Web itself might have been favored for attention. And less glamorous or newsworthy topics certainly cannot count on coverage by the popular press. Yet our results demonstrated that it is the Web links that can provide sustained growth in readership. Many such links are becoming push agents that replace traditional gatekeepers of information and knowledge. These intermediaries in the New Media fill the spectrum between value-free agents such as librarians and value judges such as editors of scholarly journals. They select and maintain hyperlinks (e.g., lists of business resources on commercial Web sites) and meta-sites (e.g., @BRINT) of specialized professional interests, potentially covering all kinds of business research. Our results show that practitioners are tuning in to these outlets. They are responding to the lighter options of information pushing and ready to exercise their own judgment regarding relevance and usefulness of what they pull in. The lesson is that if professors can "read the writing on the Web" and broaden their customer base, there is an expanding network of practitioners to tap their expertise and to provide the impetus and feedback to foster academic research. If they care to make the relevant connections, the New Media can offer new outlets to bridge the gap between academic research and business practice well beyond the transplanting of printed journal papers to the digitized Web page.

As future research, a formal theoretical framework for the push-pull of information dynamics will be useful in further comparison of alternative options in the dissemination of research results. This may lead to breakthroughs in academic evaluation. For example, if academics claim to embrace relevance, then perhaps traffic and links to one's Web site will eventually count as much as citations in the scholarly literature.

APPENDIX A

The purpose-value framework with one example of Web site feature or function in each catagory.

PURPOSE VALUE	**Promotion**	**Provision**	**Processing**
Timely	items on sale	job vacancies	online auctions
Custom	product search	custom report	custom orders
Logistic	online catalog	financial reports	delivery tracking
Sensational	contests	games	"surprise" discounts

APPENDIX B

List of 40 industries:

Accounting	Advertising	Aerospace	Airline
Apparel/Fashion	Automobile	Banking	Beverage
Brokerage	Chemicals	Computers	Construction(Materials)
Construction(Services)	Cosmetics	Data Services	Electronics
Food	Furniture	Healthcare	Hotel/Resorts
Insurance	Internet Services	Jewelry	Newspaper/Magazines
Mining/Exploration	Movie/TV	Music	Office Supplies
Oil and Gas	Paper	Pharmaceutical	Publishing
Real Estate	Software	Sports	Telecommunication
Textile	Travel	Trucking/Shipping	Wine/Spirits

APPENDIX C

Forty business and IT-related publications:

Atlanta Journal & Constitution, Boston Globe, Business Research's Interests, Business Week, Byte, Chicago Tribune, Commercial Sites Index, Computerworld, Crain Electronic Media, CyberSkeptic's Guide to Research on the Internet, Datamation, Digital N & R, Economists, E-in-C Digital News & Review, Entrepreneur, Fast Company, Financial World, Forbes, Fortune, Global Internet News Agency, Inc, Informationweek, Library of Congress Internet Statistics, Los Angeles Times, Nation's Business, NET, Newsweek, New York Times, New York Times Syndicate, PC, PC Week, PC World, Success, USA Today, Virtual City, Wall Street & Technology, Wall Street Journal, Webmaster, WebWeek, Working Women, Worth.

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Chapter XV

Assessing the Value of Information Technology Investment to Firm Performance

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The promise of increased competitive advantage has been the driving force behind the large-scale investment in information technology (IT) over the last three decades. There is a continuing debate among executives and academics as to the measurable benefits of this investment. The return on investment (ROI) and other performance measures reported in the academic literature indicate conflicting empirical findings. Many previous studies have based their conclusions on the statistical correlation between IT capital investment and firm performance data of the same time period. In this study we argue that the causal relationship between IT investment and firm performance could not be reliably established through concurrent IT and performance data. We further submit that it would be more convincing to infer causality if the IT investments in the preceding years are significantly correlated with the performance of a firm in the subsequent year. Using the Granger causality models and three samples of firm-level financial data, we found no statistical evidence that IT investments have caused the improvement of financial performance of the firms in the samples. On the contrary, the causal models suggest that improved financial performance over consecutive years may have contributed to the increase of IT investment in the subsequent year. Implications of these findings as well as directions for future studies are discussed.

INTRODUCTION

The so-called "productivity paradox" has created an increasing awareness of the issues that surround the question: What value does information technology add to an organization? The paradox is described as that "[the] delivered computing power in the U.S. economy has increased by more than two orders of magnitude since 1970, yet productivity, especially in the service sector, seems to have stagnated" (Brynjolfsson, 1993, p. 67) Here management is faced with the dilemma: Does it pay to invest in information technology (IT) provided that there are other investment opportunities?

The case literature of the 1980s and 90s attempted to show that IT provided competitive advantages to firms by adding value across all aspects of the value chain, improving operational performance, reducing costs, increasing decision quality, and enhancing service innovation and differentiation (Applegate, mcFarlan & McKenney, 1996; Porter & Millar, 1985), etc. More recent literature suggests that sustained competitive advantages can be achieved through building and leveraging key IT assets such as human resources, reusable technology and partnership between IT and business management (Ross, Beath, & Goodhue, 1996). The underlying theory is that these operational and strategic improvements as a result of effective use of IT should lead to corresponding improvements in productivity, revenue, and profits for those firms that consistently make higher investment in IT than their competitors. In the case of high-tech companies, IT often is the product or service that directly contributes to revenue and profit.

There are several empirical studies that support such arguments. Brynjolfsson and Hitt (1996) estimated that the net marginal product of IT staff is about $1.62, and that of IT capital is about 48% or better, which are at least as large as these of other types of capital investment. Mitra and Chaya (1996) showed that the firms that spent more on IT achieved lower cost of production and lower total operating cost when compared with their peers in the same industry, indicating that IT investment indeed improves operational efficiency.

However, not all studies of industry- and firm-level financial data have shown a positive causal relationship between IT investment and improved firm performance. Morrison and Berndt (1990) found that in the manufacturing sector, every dollar spent on IT only delivered on average about $0.80 of value on margin, an indication of overspending in IT. Loveman's study (1994) of 60 business units found that IT investment has a negative output elasticity, indicating that the marginal dollar would have been better spent on other categories of capital investment. Even though such a negative impact of IT on a firm's output seems unlikely and counterintuitive, it is consistent with the findings of Hitt and Brynjolfsson (1996). Their study of 370 firms showed that IT stock has negative impacts on firm performance measures, such as return on assets, return on equity, and total return, though the magnitude of such impact is quite small.

Closer examinations of these studies, however, revealed a flaw in the methodologies: the impact of IT on firm performance was tested using the IT capital data and the performance data of the same time period. Under such circumstances, the positive and significant correlation between IT capital variables and the firm performance variables has no inherent implication of a causal relationship, no matter how this correlation is established: whether it is through canonical correlation, economic production functions, or t-tests. This is because one can equally reasonably argue, given the same test results, that it is the higher revenue or profit that caused the firm to spend more on IT capital, or that firms allocate more capital spending when they anticipate better financial performance in the coming years.

In this study, we investigate the impact of IT investment on firm productivity and performance using well-accepted causal models based on firm-level financial data. We argue that no matter what theoretical or empirical models are used, with the currently available testing techniques, it is unlikely that using concurrent IT and firm performance data would yield a conclusive causal relationship between the two. We further submit that it would be more convincing to conclude that IT investment does impact firm performance if it can be shown that the IT investments in the preceding years are significantly correlated with the output level of a firm in the subsequent year, but not vice versa.

RESEARCH BACKGROUND

There is no doubt in the management and MIS literature regarding the value of information and IT in the organizational context. A major problem for senior corporate management, however, is that the "added value" that IT is supposed to deliver to a firm is difficult to discern from business financial data. This could be attributed to several causes, primarily the inability of organizations to track the return of investment in IT when the impact of such investment may cross many business processes and value-chain activities. Thus, it is often difficult for IS managers to convince senior management to invest in IT projects when other capital spending opportunities exist.

What is needed is the empirical evidence at the firm level that investment in IT does provide added value to organizations. In light of this position, measuring the effectiveness of information technology has been consistently ranked as one of the most significant issues facing corporate information systems management in the 1980s and 1990s (Brancheau, Janz & Wetherbe, 1996; Sethi & King, 1994). This pressure is only likely to increase with the increasingly fierce competition and the general trend of downsizing, which have forced top management to closely scrutinize any IT investment. As one top executive put it (Violino, 1998, p. 62): "We understand that enhancing systems is critical in today's world. But we look at every system we get to make sure there's a payback." It is likely that the decision to invest in IT will be increasingly based on the comparative financial returns of IT projects, rather than reported successful IT investment experienced by other organizations.

The necessity to understand IT investment from a value-added perspective has resulted in a new research area: information technology economics. An early study in this area was by Alpar and Kim (1990), who utilized a cost function to examine the impact of IT investment on the financial performance of commercial banks. The results were mostly mixed: IT investment was found to be negatively correlated with cost, while the relationship between the IT expense ratio and the return on equity (ROE) was insignificant in 6 out of the 8 years studied.

In the study of Mahmood and Mann (1993), Pearson correlation and canonical correlations were obtained between a set of six organization performance variables and a set of six IT investment variables using the *Computerworld* "Premier 100" companies[1] of 1989. Based mostly on the correlation, it was found that organizational performance measures, such as sales by total assets, market value to book value and return on investment (ROI), were significantly positively correlated with IT investment measures, such as IT budget as percentage of revenue and percentage of IT budget for training employees. However, it was also found that IT budget as a percentage of total revenue was significantly negatively correlated to performance measures such as sales by total assets, market value to book value and ROI.

Mitra and Chaya (1996) also used the *Computerworld* "Premier 100" companies but with 5-year data from 1988 to 1992. The relationship between IT investment and firm performance measures was tested using average values of at least three out of the five data points for each firm. Firms in the sample were grouped into different categories based on normalized z-scores of different operational and performance measures. Then t-tests and one-tailed Mann-Whitney tests were used to determine whether one group is different from another. It was found that high IT spenders had a lower average cost of operation than low IT spenders. It was thus concluded that high spenders on information technology achieve lower cost of production.

A different approach was taken by Barua, Kriebel, and Mukhopadhyay (1995) in their study of the business value of IT. Based on the premise that a firm-level analysis of IT impact may not provide meaningful guidelines to management, since medium and large firms have many IT applications in each primary and supporting value-chain activity for which the impacts are not uniform. A two-stage model was used in which the impact of IT was tested using intermediate variables, such as capacity utilization and inventory turnover. Then the impacts of these variables on firm performance measures, i.e., return on assets (ROA) and market share, were tested. It was found that IT capital had a significant impact on most of the intermediate variables, which in turn significantly affected firm performance measures, such as ROA and market share.

Using the IT spending data of large U.S. firms compiled by the International Data Group, Brynjolfsson and Hitt (1996) estimated the contribution of computer capital to the output of firms based on a set of economic production functions. Two major findings were that computer capital had a gross marginal product of 81% vs. 6.26% for noncomputer capital, and that for every dollar spent on IS labor the return was $2.62 on the margin vs. $1.07 on other labor and expenses. These led to the conclusion that the IT "productivity paradox" has disappeared by 1991 (Brynjolfsson & Hitt, 1996). In another study, Hitt and Brynjolfsson (1996) included consumer surplus on the list of dependent variables for studying the value of IT. Using the same economic production approach, it was found that the IT stock had contributed positively to the production output with a marginal product of 94% and that IT had created substantial consumer surplus over its investment. However, it is also found that IT stock has contributed negatively to profitability measures such as ROA and ROE, though the magnitude of such impact is very small.

The same economic production function approach was also used by Rai, Patnayakuni, and Patnayakuni (1997) in a recent study of the impact of IT investment on firm performance. Using firm-level IT spending data published in *Informationweek* in 1994, coupled with other financial data found in the Compustat database, the authors estimated several production functions with different performance variables (ROA, ROE, labor productivity, and administrative productivity) as the outputs and different IT investment categories (IT capital, IT budget, client/server expenditure, staff expenditure, etc.) as the inputs. Overall, it was found that IT investments were positively associated with firm performance (ROA and ROE) and labor productivity, but not with administrative productivity.

A summary of the major studies reviewed above is presented in Table 1. Mahmood and Mann (1993, p. 102) and Brynjolfsson (1993, p. 70) provide excellent reviews of some earlier studies of IT investment impact on firm performance. Overall, the literature on the IT impact on firm performance has been overwhelmingly positive. However, few of the these studies used explicit causal models, while supposedly it was the causal relationships between IT investment and firm performance that was under investigation. These studies often concluded or implied causality by asserting that IT investment impacted firm performance based on the established statistical correlation between the variables of these two factors. In essence, all that has been established in these studies is that IT investment and firm performance are related. It could be that the increase in IT investment has caused the improvement in firm performance. Or it could well be that the improvement in firm performance has caused the increase in IT investment. As indicated by Hitt and Brynjolfsson (1996, p. 137), "a key assumption of the production function approach is that input 'causes' output. Yet, it may also be true that output 'causes' increased investment in inputs, since capital budgets are often based on expectations of what output can be sold." Without the explicit testing for a causal relationship, the correlation-based models will not discover the true relationship between IT investment and firm performance.

Another flaw in the previous studies is the use of IT data and firm performance data of the same time periods. Causal relationships between two factors inferred from concurrent data assume instantaneous causality between the two factors. It is highly suspicious, if not unlikely, that such an instantaneous causal relationship exists between IT investment and firm performance. The lagged effect of IT investment on firm performance has been suspected by Osterman (1986), Brynjolfsson (1993), and Loveman (1994), though no significant empirical evidence has emerged in the literature. On the other hand, the argument for instantaneous causality between IT investment and firm performance (e.g., Rai et al., 1997) appears rather weak.

With an understanding of the significance of the issue and the apparent limitations of previous studies, we attempt to accomplish two objectives in this study. First, to determine whether there is a causal relationship between IT investment and firm performance with explicit causal modeling techniques. If such a causal relationship is found to exist, then the second objective is to determine the direction of the causal relationship. The next section presents our research model and hypotheses.

RESEARCH MODEL AND HYPOTHESES

While many of the previous studies have provided significant insight into the issue of economic value of IT to business from different perspectives, the conclusions were almost always based on the correlation between concurrent IT-related data and performance-related data. The problem is, correlation does not necessarily imply causation. These correlations can be equally logically interpreted in the opposite direction.

In a system with two observable variables or vectors of variables, X and Y, in order for a researcher to claim that X causes Y, three commonly accepted conditions must hold (Kenny, 1979, p. 3):

- Time precedence. Causal relations are assumed to be fundamentally asymmetric, while many statistical measures are symmetric. That is, for X to cause Y, X must precede Y in time. Although instantaneous causation is logically conceivable, it is usually difficult to observe. In fact, it is suggested that in many economic situations an apparent instantaneous causality would disappear if the economic variable were measured at more frequent time intervals (Granger, 1969).
- Relationship. To establish a causal-effect relationship between two variables, there must exist a functional relationship between the cause and the effect. In judging whether two variables are related, it must be determined whether the relationship could be explained by chance. Statistical methods provide a commonly accepted method of testing whether such a relationship exists in the population.
- Nonspuriousness. For a relationship between X and Y to be nonspurious, there must not be a Z that causes both X and Y such that the relationship between X and Y vanishes once Z is controlled. However, a distinction must be made between a spurious variable and an intervening variable. If X causes Z, and Z in turn causes Y, then Z is called an intervening variable. In this case, the relationship between X and Y is still considered as nonspurious.

In line with this discussion, we argue that the causal relationship, if it exists at all, between IT investment and firm performance could not be established with any degree of certainty using concurrent IT data and performance data with conventional statistical techniques. The commonly used models in many of the previous studies, such as simple and multiple linear regression, the economic productions models or the structural equation models based on instantaneous causation assumption, are certainly inconsistent with the first condition and questionable with the third condition at the best.

On the other hand, there are plenty of theoretical arguments and empirical testimonies in the literature that IT investments indeed have an impact on firm performance. According to Porter and Millar (1985), the three most important benefits that IT can provide to a firm are reducing cost, enhancing differentiation, and changing competitive scope. Thus the impact of IT investment on firm productivity and financial performance can be hypothesized as follows. IT investment increases IT capital in a firm, which leads to three main results. First, improved efficiency of operation and decision making, which reduces the number of employees, other factors being equal; or more products or services can be produced or offered, other factors being equal. Second, product innovation and differentiation, which increase the market share or demand, other factors being equal. Finally, broadened competitive scope, which leads to a larger market for the product and services, other factors being equal. In any of the cases or as a combined result, the net effect of IT investment should be increased productivity and better financial performance.

Meanwhile, it has been noted in many studies (e.g., Brynjolfsson, 1993; Brynjolfsson, Malone, Gurbaxani & Kambil, 1994; Loveman, 1994; Osterman, 1986) that it takes time to realize the effect of IT capital investment on the bottom line of firms. The logic behind this argument is convincing. The greatest benefits of any IT initiatives come not from replacing old computers with new ones or manual processes with automated ones, in which the effect of investment can be realized immediately, but from organizational and procedural changes enabled by IT, often known as business process reengineering (BPR). The effect of such changes may take years to realize (Hammer, 1990; Stoddard & Jarvenpaa, 1993). There are good reasons for such lagged effect. Significant IT projects usually take years to implement. Organization structures need time to adapt in order to take the advantage of the new or improved systems. Employees need time to be trained and re-skilled. Finally, customers and the market are the last of these time-delayed chain reactions to respond, which ultimately determines the firm performance.

In light of the preceding argument, the following research hypotheses are developed for testing the causality between IT investment and firm performance:

Hypothesis 1a: The increase in IT investment per employee by a firm in the preceding years may contribute to the reduction of operating cost per employee of the firm in the subsequent year.

Hypothesis 2a: The increase in IT investment per employee by a firm in the preceding years may contribute to the increase of productivity of the firm in the subsequent year.

Hypothesis 3a: The increase in IT investment per employee by a firm in the preceding years may contribute to the sales growth of the firm in the subsequent year.

Hypothesis 4a: The increase in IT investment per employee by a firm in the preceding years may contribute to improvement of profitability of the firm in the subsequent year.

The preceding hypotheses can be summarized into the following research model, as shown in Figure 1. The solid arrow lines represent the hypothesized causal relationships in this study, and the dashed arrow lines represent the causal relationships proposed in the previous studies.

Meanwhile, it is also reasonable to argue that the opposite causal relationships exist between IT investment and firm performance. That is, if a firm had experienced consecutive years of good financial performance, it would likely increase capital spending, including IT investment. Thus, the following causal relationships can be hypothesized:

Hypothesis 1b: The reduction of operating cost per employee by a firm in the preceding years may contribute to the increase in IT investment per employee of the firm in the subsequent year.

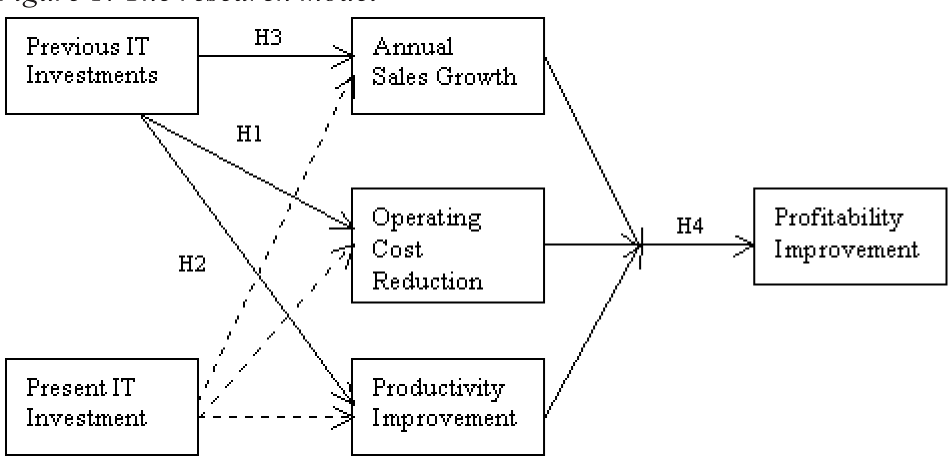
Hypothesis 2b: The increase of productivity of a firm in the preceding years may contribute to the increase in IT investment per employee by the firm in the subsequent year.

Hypothesis 3b: The sales growth of a firm in the preceding years may contribute to the increase in IT investment per employee by the firm in the subsequent year.

Hypothesis 4b: The improvement of profitability of a firm in the preceding years may contribute to the increase in IT investment per employee by a firm in the subsequent year.

We use the weaker causal relationship "contribute" rather than the stronger relationship "cause" in the hypotheses simply to reflect the fact that IT investments alone would not cause the stated effects. Many operational, technological, and economic factors play significant roles in the performance of a firm. Since we have

Figure 1: The research model



no control over those other factors, we shall not proclaim that IT investment "causes" these stated effects even if the statistical tests show the existence of the causal relationships between IT investment and these effects.

DATA AND METHOD

Data

One of the major difficulties pertaining to economic studies of IT impact on business is to obtain reliable company IT-related data, such as IT budget, IT stock value, replacement value, and IT staff, etc. This is because most companies, even the publicly traded ones, regard these data as private and competitive information. Without empirical validation, theories of IT impact on corporate performance or the value of IT to business competitiveness can only be regarded as hypotheses. Academic researchers have explored various avenues for firm-level IT data sources. Most relied on data published in industry trade publications and databases; see Table 1 for details.

It would be extremely beneficial if different studies used the same set of data sources, so that theories and inferences could be validated utilizing different research frameworks and methodologies. Unfortunately, among these sources that have firm-level IT data, only the *ComputerWorld* (CW) and the *InformationWeek* (IW) databases are publicly available. To test our hypotheses, we need a set of companies that have IT data available for at least 4 consecutive years. These companies must also be publicly traded on one of the three major exchanges (NYSE, AMEX, and NASDAQ) so that their financial data can be obtained using the widely available Compustat database. For this study, we use the IT data published in a high quality industry publication, *InformationWeek* (*IW*). IW publishes an annual list of 500 companies that it considers as the largest users of information technologies in the United States. These companies were selected based on their revenue as recorded in the Compustat database.

Like other databases, the companies in the IW 500 lists vary from year to year. In addition, the IT investment data of about half of the listed firms were either not available or were estimated by the editors of IW. In order to create reliable and accurate data sets that can be used to test our causal models and hypotheses, we constructed three separate data sets, each of which contains a set of firms that have non-estimated IT data for four consecutive years. Then we matched these firms with the Compustat database and acquired other financial data for each of the firms. The characteristics of the three data sets are shown in Table 2.

It can be seen that the companies included in the three data sets have similar characteristics: they are mostly large corporations, on average, with an annual revenue about $10 billion and annual IT spending about $340 million, and employing about 56,000 people. The companies are well distributed in a variety of industries, with banking, computer/electronics/telecom, and energy/natural resource having a slight lead over other groups.

Method

In order to test the causal relationships submitted in our research hypotheses, we must rely on the established causal modeling methods. Although the difficulties in and the need for causal modeling in MIS research had not been properly addressed until recently (see Lee, Barua, & Whinston, 1997), the literature in social sciences, especially econometric studies, has developed a rich body of alternative causality models for various social and economical issues. Among those, the Granger causal model (1969) exhibits the maximum compliance with the three preconditions of causality, even the instantaneous causation can be accommodated in the model. The major strength of Granger causality model is in testing the direction of causal effect using time-series data in a bivariate system (Holland, 1986; Sims, 1972), which provides an excellent statistical tool for testing the hypotheses we have formulated.

Let X_t and Y_t be two time-series data, the general causal model with consideration of possible instantaneous causality can be written as:

$$\begin{aligned} X_t + b_0 Y_t &= \sum_{j=1}^{n} a_j X_{t-j} + \sum_{j=1}^{n} b_j Y_{t-j} + \varepsilon_t \\ Y_t + c_0 X_t &= \sum_{j=1}^{n} c_j X_{t-j} + \sum_{j=1}^{n} d_j Y_{t-j} + \eta_t \end{aligned} \tag{1}$$

where ε_t and η_t are two uncorrelated white noise error terms with zero means.

This definition of causality implies that Y causes X if some b_j is not zero, and X causes Y if some c_j is not zero. If both of these events occur, there is said to be a feedback relationship between X and Y. If b_0 is not zero, then the instantaneous causality is occurring and a knowledge of Y_t will improve the "prediction" or goodness of fit of the first equation for X_t, and vice versa if c_0 is not zero.

Substituting X and Y in the causal model with firm IT data and performance data, we can derive a set of models for testing our research hypotheses. However, before we present the causal models specific to these hypotheses, we need to define each of the variables used to represent IT investments, operating cost, sales growth, productivity, and profitability. To minimize the impact of firm size variations in our samples, it was decided that we should use per employee metrics wherever it is applicable.

IT Investments. The three data sets provide annual IT spending of each firm for 4 consecutive years. Instead of using the actual values, the change of the annual IT investment per employee is considered as the most appropriate measure for studying the impact of IT on firm performance, defined as follows:

$$\Delta I_t = \frac{I_t / E_t - I_{t-1} / E_{t-1}}{I_{t-1} / E_{t-1}} \tag{2}$$

where I_t and I_{t-1} are the IT investments by the firm in year t and t-1, E_t and E_{t-1} are the number of employees of that firm in year t and t-1, and ΔI_t is the percentage change of IT investment per employee over the preceding year.

Table 1: IT data sources used in previous studies

Authors	Data Period	Data Source	Sample Size	Topic	Metrics for *Performance* and IT Investment	Major Findings
Alpar and Kim (1990)	1979-1986	Federal Reserve Bank of New York	624 to 759, varying year to year	IT impact on competitiveness and performance	*ROE and production cost* Ratio of IT expense to operation expense, level of computer usage	Inconclusive: IT is negatively correlated to operation cost, but insignificant to ROE.
Brynjolfsson, Malone, Gurbaxani, and Kambil (1994)	1976-1989	Bureau of Economic Analysis (BEA)	20 industries	IT impact on firm size	*Employee per firm, sales per firm, value added per firm* IT capital per firm	IT capital is strongly negatively correlated to firm size measures.
Loveman (1994)	1978-1984	Management Productivity and Information Technology (MPIT) database	60 business units of roughly 20 firms	IT impact on firm productivity	*Inventory adjusted sales per business unit* IT capital of a firm	IT capital has zero or negative correlation to business output measures.
Barua, Kriebel, and Mukhopadhyay (1995)	1978-1984	Management Productivity and Information Technology (MPIT) database	60 business units of roughly 20 firms	IT impact on firm productivity and performance	*Capacity utilization, inventory turnover, market share, return on assets, etc.* IT capital and IT purchase, employee cost	IT capital and purchase are positively correlated to intermediate measures such as capacity utilization and inventory turnover, which in turn is positively correlated to performance measures.
Mahmood and Mann (1993)	1989	*ComputerWorld* Premier 100 list	100 firms	IT impact on competitiveness and performance	*Return on investment, return on sales, growth in revenue, etc.* IT budget as percentage of total revenue, value of IT as percentage of revenue, etc.	Results are mixed. Correlation analysis shows IT investment is positively related to performance measures, while canonical analysis results are inconclusive; both positive and negative results exist.
Hitt and Brynjolfsson (1996)	1988-1992	International Data Group (IDG) annual survey database	370 firms	IT impact on firm productivity and performance	*Return on assets, return on equity, gross sales and value added (sales minus nonlabor expense)* IT stock (IT capital plus IS staff budget)	IT stock has contributed positively to total output; however, IT stock is slightly negatively correlated to profitability measures such as ROA and ROE.
Brynjolfsson and Hitt (1996)	1987-1991	International Data Group (IDG) annual survey database	Total 367 firms, average 224 firms each year in the data set	IT impact on firm productivity and performance	*Output measured by total sales* Computer capital and IS Staff Budget	Computer capital and IS staff budget are positively related to increase in output.
Mitra and Chaya (1996)	1988-1992	*ComputerWorld* Premier 100 list	448 firms, varying from year to year	IT impact on firm productivity and performance	*Operation and production costs, firm size* IT budget as percentage of sales	Firms with higher IT investment have lower operating cost, lower production cost, and higher overhead.
Rai, Patnayakuni, and Patnayakuni (1997)	1994	*InformationWeek*	497 firms, 231 had IT data	IT impact on firm productivity and performance	*Sales, return on assets, return on equity, sales per employee* IT capital, IT budget, IT staff, software	IT investment is positively related to firm output measures (sales) and profitability measures (ROE and ROA).

*Table 2: Characteristics of the firms in the data sets**

DESCRIPTION	DATA SET #1	DATA SET #2	DATA SET #3
Years Covered	1990-1993	1991-1994	1992-1995
Number of Companies	56	62	42
Revenue, μ (σ), billions	10.82 (13.54)	11.19 (13.73)	12.74 (14.93)
IT Budget, μ (σ), millions	348.88 (763.76)	357.77 (759.32)	412.85 (834.03)
Employees, μ (σ), thousand	56.28 (82.64)	58.09 (83.32)	58.64 (82.53)
Firms in Industry Groups			
Aero/Auto	4	5	4
Airline/Air Freight	3	2	0
Banking	10	9	7
Chemical	3	3	3
Computer/Electronics/Telecom	6	13	8
Consumer	1	2	1
Energy/Natural Resources	9	9	6
Financial Services	5	0	1
Food	1	3	2
Manufacturing	4	3	4
Health Care	2	3	2
Pharmaceutical	1	2	1
Publishing	3	0	0
Railroad/Transportation	1	0	0
Retailing	1	3	2
Wholesale	2	0	0

* Firms in the three data sets are not mutually exclusive, rather they overlap with each other to a fair degree. An inspection of the data sets reveals that about 50% of the companies overlap in any two adjacent data sets, and about 30% companies overlap in all three data sets.

Operating Cost. If IT investment has any impact on firm performance, the operating cost should be the most sensitive area. A firm's operating cost is measured in terms of its selling, general, and administrative expenses as reported in its annual report. In this study, we are more interested in the change of operating cost than the cost itself. Therefore, we define the change of operating cost as follows:

$$\Delta C_t = \frac{C_t / E_t - C_{t-1} / E_{t-1}}{C_{t-1} / E_{t-1}} \qquad (3)$$

where C_t and C_{t-1} are the selling, general, and administrative expenses in year t and t-1, and E_t and E_{t-1} are the number of employees of that firm in year t and t-1, respectively. ΔC_t is the operational cost reduction per employee.

Sales Growth. Annual sales growth rate is an important indicator of the competitiveness of a firm. If IT investment has any impact on firm performance, it should be reflected in the changes of sales from year to year. In this study, the sales growth is calculated as follows:

$$\Delta S_t = \frac{S_t - S_{t-1}}{S_{t-1}} \qquad (4)$$

where S_t and S_{t-1} are the annual sales of a firm in year t and t-1, and ΔS_t is the annual sales growth rate from year t-1 to year t .

Productivity. Labor productivity is defined in general as the output per unit time of labor. In this study, the output is measured in terms of sales, and the time unit is 1 year. Thus labor productivity of a firm is defined as the annual sales per employee, and the change of productivity is defined as follows:

$$\Delta P_t = \frac{S_t / E_t - S_{t-1} / E_{t-1}}{S_{t-1} / E_{t-1}} \tag{5}$$

where S_t and S_{t-1} are the annual sales of a firm in year t and t-1, E_t and E_{t-1} are the number of employees of a firm in year t and t-1, and ΔP_t is the change of productivity of the firm from year t-1 to year t.

Profitability. A firm's profitability is measured in terms of the classic ROA (return on assets) and ROE (return on equity). Since these measures are already calculated in percentages, the annual changes of profitability are simply defined as follows:

$$\Delta ROA_t = ROA_t - ROA_{t-1} \tag{6}$$

$$\Delta ROE_t = ROE_t - ROE_{t-1} \tag{7}$$

where ROA_t and ROA_{t-1} are the return on assets of a firm in year t and t-1, and ROE_t and ROE_{t-1} are the return on equity of a firm in year t and t-1.

The four pairs of research hypotheses can be tested by substituting the X's and Y's in the Granger causality model (1) with the investment and performance variables defined in equations (2) through (7).

According to the principle of the Granger causality model, there are several possible outcomes from this set of regression equations, each of which provides some insight into the relationship between the dependent variable and independent variables:

- If b_0's or c_0's are found to be significantly different from zero, then there exists an instantaneous causal-effect relationship between the change of IT investment and the change of the performance variables;
- If b_j's (j = 1, 2, … n) are found to be significantly different from zero and the same is not true for c_j's (j = 1, 2, … n), then it should be concluded that the change of IT investments in the previous years (ΔI_{t-j}, j=1, 2, …n) caused or at least contributed to the change of the performance measures (ΔC_t, ΔS_t, ΔP_t, ΔROA_t, or ΔROE_t) in the subsequent year (t);
- If c_j's (j = 1, 2, … n) are found to be significantly different from zero and the same is not true for b_j's (j = 1, 2, … n), then it should be concluded that the change of performance measures in the previous years (ΔC_{t-j}, ΔS_{t-j}, ΔP_{t-j}, ΔROA_{t-j}, or ΔROE_{t-j}, j=1, 2, …n) caused or at least contributed to the change of the IT investment (ΔI_t) in the subsequent year (t);
- If b_j's (j = 1, 2, … n) are found to be significantly different from zero and the same is true for c_j's (j = 1, 2, … n), then it should be concluded that there exists a feedback relationship between the change of IT investments (ΔI_{t-j}, j=1, 2, …n) and the change of the performance measures (ΔC_{t-j}, ΔS_{t-j}, ΔP_{t-j}, ΔROA_{t-j}, or ΔROE_{t-j}, j=1, 2, … n).

- If all of b_j's and c_j's (j = 1, 2, … n) are found to be insignificantly different from zero, then it should be concluded that there is no relationship between the change of IT investments and the change of the performance measures.

We can see that compared to the conventional regression analysis used in many previous studies, including the studies using economic production models, the tests based on Granger causality model are able to eliminate the chance of confirming false causal relationships resulted from mis-specified regression models.

RESULTS

We estimated the model parameters using the least-square linear regression method provided in the SAS software package based on the causality models defined in equation (1) and the three data sets as described in Table 2. The results are presented in Tables 3 through 7 in the appendix. Notice that since we only have the data for 4 consecutive years, and we are using the year-to-year changes as variables, the upper limit (n) for subscript j in all the models is two (j = 1, 2). As a result, the causal relationship between the proposed cause and effect variables is tested in three consecutive years (t-0, t-1, t-2).

Since multiyear financial data are involved in the regressions, inflation becomes an important factor. Before conducting the regressions, we inflated the financial figures of the preceding years to the real dollar values of the subsequent year (t) based on the annual percentage change of implicit price deflator of the gross domestic product, as published in the Survey of Current Business (U.S. Department of Commerce, 1997).

In all tables, the numbers in parentheses are the two-tailed t-statistics of the regression parameters, and the statistical significant levels are represented as: *** for $p < 0.01$, ** for $p < 0.05$, and * for $p < 0.1$.

DISCUSSIONS

The tables in the Appendix presented a large amount of data about the estimated causality models and their associated testing statistics. To facilitate our discussion, these results are summarized in Tables 8 and 9 and organized based on the research hypotheses.

The results in Table 8 speak out loud and clear: there is no convincing evidence that IT investments in the preceding years have made any significant contribution to the subsequent changes in any of the four categories of firm performance measures: operating cost, productivity, sales growth, and profitability. The only noticeable significant b parameter is the one for the effect of IT investment on the ROA in the 1990-1993 data set ($b_1 = 0.0470$, significant at $p<0.01$ level). The implication is that the increase of IT investment in the time period of 1991-1992 had contributed to the increase of ROA in 1993 of the firms in the data sets. However, given the overall nonsignificant tone of the results, this one case of significance is not enough to be considered as convincing evidence to conclude that IT investment has a positive impact on firm profitability.

On the other hand, there is clear evidence to support the hypotheses that firms budget their IT investment based on the financial performance of preceding years, especially the sales growth, as shown in Table 9. In two out of the three data sets, either c_1 or c_2 was found to be significantly greater than zero for Hypothesis H3b. Since the opposite hypotheses H3a, is not true, we can conclude with a fair degree of certainty that the changes in sales growth in the preceding years had contributed to the changes of IT investment in the subsequent year: the faster the sales growth was achieved, the more money was allocated for IT investment.

This conclusion is further supported by the measures of goodness of fit of all linear regression models. It can be seen from Tables 3 through 7 that when IT investment is used as the effect (dependent variable) and the measures of financial performance as the cause (independent variable), most models' F-statistics are significant at $p < 0.05$ level and R^2-adj.'s are at decent levels. When the measures of firm performance are used as the effect and the IT investment as the cause, most F-statistics are insignificant at $p < 0.05$ level and R^2-adj.'s are very small.

Table 8: Hypotheses with IT investment as cause and performance as effect

Hypotheses	**Data Sets**		
	1990-1993	1991-1994	1992-1995
H1a	$b_1 = b_2 = 0$ No support	$b_1 = b_2 = 0$ No support	$b_1 = b_2 = 0$ No support
H2a	$b_1 = b_2 = 0$ No support	$b_1 = b_2 = 0$ No support	$b_1 = b_2 = 0$ No support
H3a	$b_1 = b_2 = 0$ No support	$b_1 < 0$*, $b_2 = 0$ Negative impact	$b_1 = b_2 = 0$ No support
H4a	$b_1 > 0$***, $b_2 = 0$ Partial support	$b_1 = b_2 = 0$ No support	$b_1 = b_2 = 0$ No support
	$b_1 > 0$*, $b_2 = 0$ Partial support	$b_1 = b_2 = 0$ No support	$b_1 = b_2 = 0$ No support

Significant level: *** p<0.01, ** p<0.05, * p<0.1

Table 9: Hypotheses with performance as cause and IT investment as effect

Hypotheses	**Data Sets**		
	1990-1993	1991-1994	1992-1995
H1b	$c_1 = c_2 = 0$ No support	$c_1 > 0$***, $c_2 = 0$ Negative support	$c_1 = c_2 = 0$ No support
H2b	$c_1 = c_2 = 0$ No support	$c_1 > 0$**, $c_2 = 0$ Partial support	$c_1 = c_2 = 0$ No support
H3b	$c_1 < 0$**, $c_2 = 0$ Partial support	$c_1 > 0$***, $c_2 = 0$ Partial impact	$c_1 = 0$, $c_2 > 0$*** Partial support
H4b	$c_1 = c_2 = 0$ No support	$c_1 = c_2 = 0$ No support	$c_1 = c_2 = 0$ No support
	$c_1 = c_2 = 0$ No support	$c_1 = c_2 = 0$ No support	$c_1 = c_2 = 0$ No support

Significant level: *** p<0.01, ** p<0.05, * p<0.1

We also found no evidence to support the hypothesis that there is an instantaneous causality between IT investment and firm performance, as implicitly assumed in many of the previous studies when concurrent IT data and performance data are used to test the causal relationship. According to the principle of Granger causality, if there exists an instantaneous causal relationship between IT investment and firm performance, then either coefficient b_0 or c_0 would be significantly different from zero. Examining Tables 3 through 7, none of the b_0 or c_0 are significantly different from zero at the $p<0.05$ level. This result casts serious doubt on the research methodology that uses concurrent data for testing a causal relationship between IT investment and firm performance.

It should be noted that the effect of industry differences and IT maturity levels of firms on their performance and productivity is not considered in our models and tests due to the limitations of the data sets. Previous studies of such effect (e.g., Brynjolfsson et al, 1994; Loveman, 1994; Mitra & Chaya, 1996) have shown mixed results.

CONCLUSIONS

We have shown, through tests using the Granger causality models and firmly level data, that the hypothesized positive causal relationship between IT investment and firm performance cannot be established at acceptable statistically significant levels. On the other hand, there is clear evidence that firms had budgeted IT investment based on the financial performance of the preceding years, especially the growth rate of annual sales.

The results of this study have a number of significant implications for future studies of the economic value of IT investment. The first is that many firms, if not all, may have failed to capitalize on their investments in IT through reengineering business processes (Hammer, 1990) and other organizational changes. Year after year firms adjust, usually upward, their IT budget based on the previous year's level simply because their competitors and other members of the industry are doing the same. New versions of software and ever more powerful hardware replace the existing ones, even if they are still adequate for the applications they support. Detailed examinations of how firms actually allocate their IT budget and the subsequent changes are warranted and may shed some light on why IT investments have failed to show at the bottom line of organizations.

Second, overspending in IT by firms may be another complicating factor. Marginal analysis by Morrison and Berndt (1990) shows that every additional \$1 spent on IT only delivers \$0.80 in output. This is essentially the same as the findings of two other studies (Brynjolfsson & Hitt, 1996; Hitt & Brynjolfsson, 1996) using different data sets. A recent report by Sentry Technology Group based on a survey of 16,000 large U.S. companies estimates that as much as \$66 billon–nearly 10% of total IT purchases–could go into the "inefficient" IT spending category, including purchases of unused or underused hardware, software, and services (Violino, 1997a). "It has become so easy to spend a lot of money on hardware, software, and maintenance–and not necessarily see any return," said one executive (Violino, 1998, p. 61). Policies and practices for better IT asset management may be another important area that has been overlooked by both practitioners and academia.

Our final concern is the issue of measurement. Although most studies of the economic value of IT, including the present one, have attempted to associate IT investment with aggregated firm performance measures, such as ROA and ROE, other alternatives have been proposed. Barua et al. (1997) advocate the use of intermediate variables (e.g., capacity utilization and inventory turnover) to study the impact of IT since they reflect the direct impact of IT investment. From a different perspective, Brynjolfsson (1996) suggests that if the impact of IT investment fails to show up in the statistics of producers' performance data, it should be reflected in the surplus that has benefited consumers through lower prices of the products due to the use of IT by the producers.

While both studies provided empirical evidence that support the hypotheses, one central question is: No mater how much IT has contributed to the consumer surplus or the capacity utilization rate, what is the value of IT investment to shareholders if it fails to increase the profitability of a for-profit organization? "Business leaders, IS executives, consultants, and academics for years have debated whether it's necessary or even desirable to measure IT's return on investment. But the discussion is being cut short by CEOs and chief financial officers with their eyes on the balance sheet. Before granting funds for a major project, these execs are demanding to see the expected payback–in financial terms they understand" (Violino, 1998, p. 61).

It seems that we have raised more questions than provided answers in this study. This is perhaps a reflection of the ongoing debate about the economic value of information technology and how it should be measured properly (Violino, 1997b, 1998). It is our hope that this study will assist in moving the focus of future research on the economic value of IT from the discovery of statistical correlations to the development of new metrics and methodologies that are appropriate for evaluating the causal relationship between IT investment and firm performance.

ENDNOTE

1 *Computerworld* is one of the premier national publications on corporate IS related news and issues. It publishes a list of 100 public companies annually named the "*Computerworld* Premier 100" selected from 1,000 companies based on how effectively they uses IT. The criteria used to rank the companies, however, are not consistent from year to year. See *Computerworld* Premier 100 for details (e.g., September 11, 1989, and October 9, 1995) .

APPENDIX

This section presents the test results of the various hypothesized causal relationship in the study. All data are reported in terms of regression coefficient with its t-statistic value in parentheses where applicable.

Table 3: The causal relationship between IT and operational cost

	Data Sets		
	1990-1993	1991-1994	1992-1995
Parameters	*Operational Cost as the Effect*		
R^2-adj.	-0.0459	0.1627	0.1120
F-statistic	0.6312	**3.0202	1.9335
Intercept	4.8519 (1.2325)	1.2415 (0.4125)	***9.1060 (3.3979)
a_1	-0.0853 (-0.2480)	-0.0083 (-0.0594)	*-0.4417 (-1.9457)
a_2	-0.0870 (-0.2129)	**0.3893 (2.2898)	-0.0942 (-0.3434)
b_0	0.0836 (1.6596)	0.0768 (0.9193)	0.0808 (1.2834)
b_1	0.1489 (1.1798)	-0.0900 (-0.8141)	-0.0898 (-1.3426)
b_2	-0.0154 (-0.2345)	0.0729 (0.8941)	-0.0708 (-0.8610)
	IT Investments as the Effect		
R^2-adj.	0.2837	0.1535	-0.0096
F-statistic	***4.3273	**2.8865	0.9293
Intercept	3.0963 (0.2449)	0.9421 (0.1806)	9.0610 (1.0772)
c_0	0.8291 (1.6596)	0.2300 (0.9193)	0.6060 (1.2834)
c_1	0.6377 (0.5911)	***0.7139 (3.2623)	-0.5779 (-0.8897)
c_2	0.3931 (0.3058)	0.2100 (0.6804)	-0.5031 (-0.6731)
d_1	***-1.3763 (-4.0982)	-0.1912 (-1.0027)	0.0467 (0.2481)
d_2	-0.1909 (-0.9315)	-0.1552 (-1.1055)	-0.1580 (-0.6988)

Table 4: The causal relationship between IT and productivity

	Data Sets		
	1990-1993	1991-1994	1992-1995
Parameters	*Productivity as the Effect*		
R^2-adj	0.0374	0.2568	0.0731
F statistic	1.4273	***5.2165	1.6471
Intercept	2.8143 (1.0971)	4.5869 (2.0858)	10.7476 (4.1925)
a_1	0.3107 (0.3077)	-0.0727 (-0.7407)	-0.2226 (-1.5291)
a_2	0.1966 (0.7719)	***0.4988 (3.4739)	0.0951 (0.4678)
b_0	-0.0619 (-1.4358)	*0.1217 (1.9925)	*0.1143 (1.8257)
b_1	-0.1270 (-1.6106)	-0.0483 (-0.6531)	-0.0253 (-0.3766)
b_2	-0.0367 (-0.6435)	0.0696 (1.1894)	-0.0356 (-0.4753)
	IT Investments as the Effect		
R^2-adj.	0.2700	0.1159	0.0256
F-statistic	***5.0688	**2.5992	1.2158
Intercept	16.1826 (2.0148)	-0.0326 (-0.0068)	5.1805 (0.6543)
c_0	-0.6402 (-1.4358)	*0.5440 (1.9925)	*0.7413 (1.8257)
c_1	-0.8114 (-1.0553)	**0.5209 (2.6488)	-0.2804 (-0.7385)
c_2	-0.4316 (-0.5252)	-0.1218 (-0.3642)	-0.1353 (-0.2608)
d_1	***-0.9298 (-4.1434)	0.0007(0.0043)	0.0671 (0.3924)
d_2	-0.2100 (-1.1533)	-0.0604 (-0.4839)	-0.1450 (-0.7639)

Table 5: The causal relationship between IT and sales growth

	Data Sets		
	1990-1993	1991-1994	1992-1995
Parameters	*Sales Growth as the Effect*		
R^2-adj.	0.0563	0.3027	-0.1177
F-statistic	1.6562	***6.2953	0.1362
Intercept	7.8706 (1.5032)	***6.9156 (4.6003)	***12.2512 (2.8656)
a_1	0.2652 (0.7117)	***0.2457 (2.9643)	0.0146 (0.0485)
a_2	0.5320 (1.6358)	***0.4640 (3.8513)	0.1064 (0.4357)
b_0	-0.1440 (-1.5658)	-0.0153 (-0.3686)	-0.0760 (-0.6748)
b_1	-0.0119 (-0.0607)	*-0.0909 (-1.9744)	-0.0454 (-0.3803)
b_2	-0.0595 (-0.4986)	-0.0115 (-0.3250)	0.0369 (0.3260)
	IT Investments as the Effect		
R^2-adj.	0.3319	0.0666	0.3071
F-statistic	***5.9859	1.8710	***4.6335
Intercept	**18.4446 (2.4261)	1.9846 (0.3493)	11.1464 (1.6599)
c_0	-0.3246 (-1.5658)	-0.1586 (-0.3686)	-0.1644 (-0.6748)
c_1	**-1.1285 (-2.0925)	***0.7302 (2.7019)	-0.3805 (-0.8699)
c_2	0.0845 (0.1687)	-0.1780 (-0.4083)	***1.3195 (4.6304)
d_1	***-1.1535 (-4.6949)	0.0912 (0.5964)	**-0.3542 (-2.1368)
d_2	-0.2724 (-1.5531)	0.0482 (0.4218)	-0.0383 (-0.2297)

Table 6: The causal relationship between IT and profitability: ROA

	Data Sets		
	1990-1993	1991-1994	1992-1995
Parameters	*ROA as the Effect*		
R^2-adj.	0.0822	0.0512	0.0824
F-statistic	1.9851	1.6588	1.7362
Intercept	-0.1784 (-0.3515)	0.6810 (0.7691)	0.7811 (1.2644)
a_1	0.0443 (0.3210)	**-0.3516 (-2.1276)	-0.2356 (-1.1410)
a_2	***-0.3526 (-2.6759)	**-0.5123 (-2.4413)	-0.0180 (-0.1105)
b_0	0.0078 (0.9466)	0.0110 (0.4681)	0.0169 (1.0543)
b_1	***0.0470 (2.6962)	-0.0208 (-0.7515)	0.0054 (0.3160)
b_2	0.0007 (0.0649)	0.0105 (0.4964)	0.0207 (1.0912)
	IT Investments as the Effect		
R^2-adj.	0.2256	-0.0387	-0.0134
F-statistic	***4.2052	0.5460	0.8914
Intercept	18.0419 (2.1995)	2.7491 (0.5434)	10.4976 (1.6893)
c_0	2.2439 (0.9468)	0.3558 (0.4681)	1.7697 (1.0543)
c_1	-1.6436 (-0.7065)	0.9401 (0.9680)	-0.6286 (-0.2928)
c_2	2.7118 (1.1535)	0.7795 (0.6218)	-1.7159 (-1.0431)
d_1	***-1.1368 (-4.1846)	0.1173 (0.7418)	0.0286 (0.1645)
d_2	-0.2025 (-1.0752)	0.0768 (0.6397)	-0.1483 (-0.7590)

Table 7: The causal relationship between IT and profitability: ROE

	Data Sets		
	1990-1993	1991-1994	1992-1995
Parameters	*ROE as the Effect*		
R^2-adj.	0.8627	0.3184	0.1489
F-statistic	***70.1165	***6.6997	*2.4445
Intercept	2.6733 (0.8574)	**5.4298 (2.3329)	3.4128 (1.6514)
a_1	***-0.8161 (-15.6229)	*-0.3600 (-1.8349)	**-0.3017 (-2.7028)
a_2	***-0.9930 (-4.3222)	***-0.4960 (-3.3458)	-0.0008 (-0.0126)
b_0	0.0199 (0.3879)	0.0192 (0.3155)	0.0592 (1.1040)
b_1	*0.1835 (1.7117)	-0.0487 (-0.6560)	0.0329 (0.5754)
b_2	-0.0477 (-0.6906)	-0.0025 (-0.0462)	0.0406 (0.6485)
	IT Investments as the Effect		
R^2-adj.	0.2173	-0.0487	-0.0092
F-statistic	***4.0532	0.4340	0.9256
Intercept	**17.7230 (2.1442)	2.4833 (0.4653)	8.3025 (1.2958)
c_0	0.1506 (0.3879)	0.0924 (0.3155)	0.5534 (1.1040)
c_1	0.0200 (0.0575)	0.3850 (0.8747)	0.3853 (1.0447)
c_2	0.8346 (1.1418)	0.2853 (0.8057)	-0.1476 (-0.7450)
d_1	***-1.0840 (-4.1402)	0.1112 (0.6833)	-0.0279 (-0.1588)
d_2	-0.2046 (-1.0856)	0.0951 (0.8024)	-0.1299 (-0.6783)

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Chapter XVI

Some Evidence on the Detection of Data Errors

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Data stored in organizational databases have a significant error rate. As computerized databases continue to proliferate, the number of errors in stored data and the organizational impact of these errors are likely to increase. The impact of data errors on business processes and decision making can be lessened if users of information systems are able and willing to detect and correct data errors. However, some published research suggests that users of information systems do not detect data errors. This paper reports the results of a study showing that municipal bond analysts detect data errors. The results provide insight into the conditions under which users in organizational settings detect data errors. Guidelines for improving error detection are also discussed.

INTRODUCTION

Data stored in organizational databases have an error rate between 1 and 10% (Laudon, 1986; Madnick & Wang, 1992; Morey, 1982; Redman, 1992). As computerized databases continue to proliferate and as organizations become increasingly dependent upon these databases to support business processes and decision making, the number of errors in stored data and the organizational impact of these errors are likely to increase. For example, strategies such as total quality management may be difficult to implement if the required data are not of adequate quality (Fox, Levitin & Redman, 1993; Madnick & Wang, 1992; Redman, 1995).

Possible approaches for managing data errors in organizations include: (1) validating data during input or storage (e.g., Morey, 1982) and (2) relying on detection and correction of errors by end users. While useful, automated approaches to data validation do not generally yield completely accurate data. Indeed, Orr (1998) argues that unused data will become inaccurate over time. The best approach to reducing data errors in most organizations will include both automated data validation and user detection of errors. This paper examines user detection of data errors in the profession of municipal bond analysis.

The remaining sections of this paper present (1) a review of prior research, (2) a theory of error detection, (3) the research design, (4) the empirical results, and (5) a discussion of the implications of the results.

BACKGROUND

Several conclusions can be drawn from the literature on data quality. First, while no definition of data quality has been completely accepted, there is agreement that accuracy, currency, and completeness are important aspects of data quality (Agmon & Ahituv, 1987; Davis & Olson, 1985; Fox et al., 1993; Huh, Keller, Redman & Watkins, 1990; Madnick & Wang, 1992; Wand & Wang, 1996; Zmud, 1978). A broader perspective on data quality, which is gaining widespread acceptance among data quality researchers and practitioners, includes 15 dimensions of data quality: believability, accuracy, objectivity, reputation, value-added, relevancy, timeliness, completeness, appropriate amount of data, interpretability, ease of understanding, representational consistency, concise representation, accessibility, and access security (Strong, Lee & Wang, 1997; Wang & Strong, 1996). Second, error rates significantly greater than zero have been found in several studies (Ham, Losell & Smieliauskas, 1985; Johnson, Leitch & Neter, 1981; Knight, 1992; Laudon, 1986; Stone & Bublitz, 1984). Third, researchers disagree about the extent to which efforts to rid databases of errors should be undertaken. Some advocate methods designed to completely eliminate errors from databases (Janson, 1988; Naus, 1975; Parsaye & Chignell, 1993; Svanks, 1988; Wang, Lee, Pipino & Strong, 1998). Others propose methods for allocating limited resources to data quality initiatives (Ballou & Pazer, 1987; Ballou & Tayi, 1989; Ballou, Pazer, Belardo & Klein, 1987; Bowen, 1992; Paradice & Fuerst, 1991). Fourth, approaches for using imperfect data have been proposed (Ballou & Pazer, 1985, 1987, 1995; Bansal, Gaba & Winkler, 1992; Garfinkel, Kunnathur & Liepins, 1986; Kauffman & Weitz, 1993; O'Leary, 1993; O'Neill & Vizine-Goetz, 1988).

Related research has examined errors in spreadsheets (e.g., Panko, 1998) and user assessments of the quality of Internet-based information (Alexander & Tate, 1999; Klein, 2001; Rieh & Belkin, 1998).

The early literature on data quality suggests that users are not effective at detecting errors in data. Davis, Neter and Palmer (1967) found that half the people asked to verify their banking account information with imbedded errors failed to detect the errors. Laudon (1986) found that users of criminal information systems rarely detect errors in this data. Ricketts (1990) found that over 90% of the people participating in a laboratory experiment failed to detect a data error in production planning reports. Much of the literature on data quality assumes that humans will fail to detect data errors and argues that resources should be allocated to the improvement of data quality as data are input to databases (e.g., Redman, 1992, 1995).

More recent studies provide evidence challenging the conclusion that users are poor at error detection. The first of these studies found that users in one business domain (actuarial science) detect errors in data (Klein, 1997). Base rate expectations developed through direct experience with data, incentive structures, and error detection goals have been shown to affect performance in the detection of data errors in laboratory experiments (Klein, forthcoming; Klein, Goodhue & Davis, 1997). A field study was conducted to link the findings of these laboratory experiments to practice in organizations and to improve our understanding of how users in organizations respond to data errors. Findings of interviews with municipal bond analysts conducted as part of the field study are reported here.

THEORETICAL FRAMEWORK

This research relies on a theory of individual task performance and theories of effort and accuracy in decision making.

Theories of Individual Task Performance

Campbell's (1990; Campbell & Pritchard, 1976) theory of individual task performance (depicted in Figure 1) suggests that experience (e.g., Weber, Bockenholt, Hilton & Wallace, 1993), knowledge, and effort (e.g., Payne, 1982; Payne, Bettman & Johnson, 1988) all affect error detection. The theory suggests that task performance is a function of an individual's declarative knowledge, procedural knowledge and skills, and motivation. Declarative knowledge is defined as knowledge of the facts required to complete a task. Procedural knowledge refers to skill-based knowledge about how to perform a task. Education, training, and experience affect declarative knowledge and procedural knowledge. Motivation is affected by the choice to expend effort, the choice of the degree of effort to expend, and the choice to persist in task performance (Campbell, 1990).

We view error detection as a specific component of some jobs that is influenced by declarative knowledge, procedural knowledge and skills, and choices related to motivation. Task performance is viewed as the successful or unsuccessful detection of a data error. Declarative knowledge and procedural knowledge affect error detection performance. We argue that differences in expectations about the base rate of errors in data and assessments of the payoffs of error detection affect error detection through the choices related to effort.

Figure 1: Determinants of individual task performance

Performance = f(declarative knowledge,
procedural knowledge and skills,
choice to expend effort,
choice of degree of effort to expend,
choice to persist)

Experience and Knowledge

Significant amounts of experience are necessary for the development of expertise (e.g., Ericsson & Chase, 1982; Johnson, Grazioli & Jamal, 1992a; Johnson, Grazioli, Jamal & Zualkernan, 1992b). This suggests that the actual number of errors that users encounter will influence performance if they recognize the problem and try to detect the errors. A high base rate of errors may facilitate the development of declarative knowledge about the number and types of errors in data. Users working with data containing many errors also have opportunities to develop the procedural knowledge and skills needed to detect errors. Thus, users in professional domains with a high base rate of errors may develop effective strategies for error detection. These strategies may enhance error detection performance.

Effort

Expectations about the base rate of errors in data and user assessments of the payoffs of error detection may affect users' effort expended to detect data errors. Choices about the degree of effort to expend in the detection of errors will in turn influence performance. Several factors influencing these choices are suggested by an analysis of data collected in an earlier study on the use of imperfect data by actuaries (Klein, 1997). Factors influencing choices related to effort in error detection are discussed below.

Expectations About the Base Rate of Errors in Data. There is evidence from the study of the actuaries that expectations about the base rate of errors in a source of data influence effort expended in error detection. Greater effort may be devoted to error detection when users expect more errors in data because of a belief that more errors will be found at any level of expended effort. Related research shows that decision makers are sensitive to base rates in the generation of hypotheses in diagnostic tasks (Weber et al., 1993).

Payoffs of Error Detection. A task described by a subject in the study of actuaries will be used to illustrate the impact of assessments of payoffs on error detection performance. The task was the determination of whether an organization's financial reserves for its pension fund were sufficient. This judgment depends in part on the pay rate and the number of years of organizational service of each employee in the organization. Data provided by a client included this information along with other personnel information for each employee as of the end of the year. Imagine a specific case in which this data (as of the end of 2001) contains a record holding information about an accountant in a position requiring a CPA certificate in which the value of the date of birth field is "December 31, 1976" and the value of the number of years of service field is "10."

An actuary using this data might or might not suspect that the data in one of these fields is wrong (i.e., it is unlikely that a firm would hire an accountant at the age of 15). An actuary analyzing a pension fund might be likely to detect this error because it is material to the judgment about the sufficiency of the firm's pension reserves. On the other hand, a payroll manager reviewing the same data set might be unlikely to find the error because errors in the date of birth and number of years of service fields are not material to a firm's payroll.

Materiality. Thus, beliefs about the materiality of a potential error may influence the degree of effort expended to detect the error. Users may expend more effort to detect errors that they believe will have a significant impact on their calculations or decisions. There is evidence from the study of actuaries that the impact of data errors on the work being performed using the data is considered in the determination of the level of effort to expend in error detection. For example, one actuary stated that there are some types of errors that he does not try to detect when pricing insurance because the errors would not have a significant impact on his calculations.

Incentives. Organizational incentives may also play an important role in users' assessments of the payoffs of error detection. For example, an incentive system that discourages the use of time to investigate and correct errors may create an environment in which many errors in data go unnoticed.

Ease of Verification and Correction. The degree of effort expended to detect an error may also be affected by the ease with which an error can be corrected. Users may not expend much effort to detect errors if it is difficult to confirm that a suspected error is actually an error or if a confirmed error cannot be corrected.

Theories of Effort and Accuracy in Decision Making

Theories of effort and accuracy in decision making assume that humans will devote no more mental resources or effort to a task than what is demanded by task requirements. Performance in the task of error detection may therefore be sensitive to the performance requirements implicit in payoffs for error detection. Payne (1982; Johnson and Payne, 1985; Payne et al., 1988) demonstrated that the selection of information processing strategies is influenced by task requirements. In an examination of the impact of incentives on information use and performance, Cryer, Bettman & Payne (1990) found that an incentive scheme rewarding accuracy leads to more normative information processing and higher levels of task performance while an incentive scheme rewarding the minimization of effort leads to the use of heuristic processing and lower levels of task performance. This finding supports the contention that error detection performance may be sensitive to variation in payoffs.

METHODOLOGY

The investigation began with an interview with one domain expert in the field. The a priori expectations stemming from this initial interview are summarized below.

Municipal bond analysts work with data presented in the financial statements of not-for-profit organizations and state and local governments. An initial interview with a municipal bond analyst at a large investment bank suggested that the base rate of errors in the data with which these professionals work is low and that effort to detect errors is also low. The informant in the initial interview acknowledged that there are some errors in this data. However, he said that he does not actively look for errors when working with the data. One factor that could influence effort in this domain is that some of the data with which bond analysts work is audited by public accountants before it is used. The analysts may therefore assume that the most significant errors in this data have already been detected. It is possible that effort to detect errors among this group of professionals is low because any problems stemming from undetected errors could be attributed to the failure of the external auditors to detect the errors. The initial investigation also suggested that the ease of verifying and correcting data errors is low in this domain.

Following the initial investigation into the domain, five municipal bond analysts were interviewed. To control for selection bias, potential interviewees were asked to participate in a study of the use of data in their work. The terms "error detection" and "data quality" were not used when recruiting subjects. Data were collected using a semi-structured interview. Several of the questions in the interview protocol are a variation on the critical incidents methodology developed by Flanagan (1954). These questions were designed to elicit descriptions of incidents in which the interviewees successfully detected errors in data and incidents in which errors were missed.

The semi-structured interviews were recorded and transcribed. An analysis of the interview transcripts was performed using methodologies outlined by Miles and Huberman (1994) and King (1994). A coding scheme based on the theoretical framework was developed, and the transcripts were coded using this scheme.

RESULTS

The discussion of the analysis of the interviews with the municipal bond analysts begins with descriptions of the reported error detection incidents described by the five municipal bond analysts. Next, strategies that the municipal bond analysts believe they use to find data errors are discussed. The remaining sections cover reports of data errors that were missed, perceptions of payoffs for error detection in the domain, perceptions of the base rate of errors in the domain, and evidence about the extent to which the municipal bond analysts believe that detecting data errors is a part of their job responsibilities.

Reports of Error Detection

All five of the interviewed municipal bond analysts reported at least one specific error detection incident. One of the municipal bond analysts described an incident in which two hospital utilization reports with different data values were received from a hospital. Both reports provided values for the same key financial indicators for the same fiscal quarter. However, one report listed admissions of 2344, patient days of 18,445, and average length of stay of 7.9. The other report listed admissions of 3077, patient days of 19,406, and average length of stay of 6.3. The analyst did not know why the data values on the two reports were different.

Another municipal bond analyst said that errors sometimes occur in reports that are internally generated for presentation to the organization's board of directors. For example, reports categorizing the bonds held in the firm's portfolio sometimes include a holding more than once and sometimes omit a holding. A third municipal bond analyst reported finding data errors in standard reports published by research firms that rank securities based on expected return under various scenarios. Errors in ad hoc reports purchased from outside research firms were also reported.

Only one of the municipal bond analysts reported detecting data errors in audited financial statements. The other four analysts said that they find errors in unaudited reports, such as new offering statements, interim financial reports, hospital utilization reports, and loan portfolio reports, but that they do not find data errors in audited financial statements.

> *When we're looking at the deal originally, ... the numbers we get are usually audited by an accountant, so the chances of getting bad information there are pretty slim.*
>
> *In terms of audited financial statements it's very difficult to spot errors because I'm not an auditor. I don't have access to the books.*

Detection Strategies

Municipal bond analysts detect data errors when their expectations about acceptable ranges for data values and their expectations about changes in data values over time are violated. Two of the analysts reported examining reports for changes in data values over time.

> *You look at month-to-month changes ... if last month you had 12% of the portfolio in hospitals, and this month you come up with 45, you know you didn't triple your amount in hospitals.*
>
> *I get these time period reports ... and you expect to see some consistency from month to month ... and you'll see something inconsistent with the month preceding or following that data point.*

The municipal bond analysts also reported finding errors when their expectations about data values were violated.

> *They're listing the security and the security type, and the expected returns are out of line given what I would be expecting in the market.*
>
> *The return characteristics were not what I expected. ... The results didn't make intuitive sense.*
>
> *It's sort of the training of my eye over time to recognize ... acceptable ranges for some of these statistics and some of the ratios and where I may have an outlier it certainly would catch my eye because it either represents a mistake or a significant change in the risk profile of a credit.*

Two of the municipal bond analysts also said that the effort they devote to error detection is influenced by the data source.

Some of the smaller firms, I tend to be more suspect of the information they publish. ... The offering circulars of the major issuers, I would tend to rely on much more heavily.

It depends on the originator, because a more experienced originator will have a very low error rate, because they know it's important to keep good data. Whereas somebody who's just getting started, they may have a higher level of errors.

A lot depends on who is providing the information.

Errors That Are Missed

Two of the municipal bond analysts reported learning about instances in which data errors in audited financial statements were missed.

Once there was a mistake in an audit that was mailed out and digested and analyzed by the credit community. The mistake was discovered long afterwards.

On occasion I'll get a follow-up letter saying in the audit we sent you there was a mistake on such and such a page.

There's a case going on now where there's a bond issue, there was an escrow set up to secure a previous bond issue ... the mathematical equation to ensure that the escrow would be sufficient to pay off the old bonds was wrong. So now the bonds are in default. That was a pretty gross error by the mathematical consultant.

The municipal bond analysts also acknowledged that they miss data errors in unaudited reports.

In a lot of the published research, there will be an error that's not blatantly obvious, but we get informed of it later ... I would say about 90% of those I don't catch, because I'm not looking at the raw numbers, I'm looking at their summary numbers.

I'm assuming that they probably make other mistakes that I'm not catching because they're small, or minute, or they tend to match what the information should look like so I don't notice. And I think there's a lot of that going on.

I don't stay up nights worrying about it [errors that have been missed]. I'm sure it's happened once or twice, or maybe even more than that. I'm sure there are cases where I did not know [about data errors].

Payoffs

Contrary to our a priori expectations, the municipal bond analysts perceive the payoffs of detecting data errors to be high. Strong incentives to detect errors in data were reported, and the municipal bond analysts stated that some data errors are material. Although the source of the data seems to affect the ease with which suspected errors can be verified and corrected, at least some of the time verification and correction are not difficult.

Incentives

The municipal bond analysts agreed that there are strong incentives to detect errors in data.

> *The incentive is obviously monetary. And to the extent that you're keeping people out of trouble or making them money, it's to your benefit to spot and correct errors.*
>
> *I think there's a high incentive for people to spot errors and try to get the correct information and data before they buy bonds.*
>
> *There are very strong incentives to check for accuracy in data. Because a lot is riding on it and I have to rely on that data to be able to identify value in the market. ... Accuracy is probably the most critical component of my job responsibilities.*

One of the municipal bond analysts noted that although error detection is not a component of the formal incentive structure in his organization, analysts may be indirectly rewarded when errors are detected.

> *If you find errors or you find a misrepresentation, you'll be rewarded at the end of the year if there indeed were misrepresentations and it turns out later that we didn't buy the deal.*

Another analyst noted that the incentive to detect errors is particularly strong when bonds are sold to noninstitutional investors.

> *If we're doing business on a retail basis, you especially want to have good data because they are basically considered non-sophisticated investors, whereas institutional investors are considered sophisticated.*

Materiality

The municipal bond analysts believe that some types of data errors are material. One of them noted that this is particularly true of data errors in new offering statements of bonds.

In certain cases it could have a significant impact ...Probably the [errors] in the new offering statements [would be the most material] because that's where they're basically coming clean on everything.

Three of the municipal bond analysts noted that data errors could materially affect their decisions to purchase and sell bonds.

There are some errors that could be very significant and would alter our numbers in such a way that if it wasn't spotted, that we would buy a deal we normally wouldn't buy or pass up a deal that we would have liked to have bought because of that error.

The stakes are very high. ... Errors in the data that I use could have a very significant impact on the way I'm doing my job because again I'm relying on the accuracy of those numbers to make decisions or to play a role in the decision making out on the trading desk.

I would say in at least a couple of instances, we could have purchased something that we wouldn't have otherwise purchased.

Another analyst noted that errors in data can affect his understanding of the dynamics of the market for bonds.

It's also a learning process, and we're always trying to establish norms and so forth. And to the extent that we get bad data, it throws off our understanding of the market in general.

Verification and Correction of Errors

In some cases, verifying suspected data errors and correcting data errors is not difficult. For example, some errors in new offering statements are easily corrected.

I call the financial advisor ... and I say this doesn't look right. What's going on here? Is it right, is it not right?

They'll fix it immediately ... because usually what I'm calling them on is very blatant and obvious.

One of the municipal bond analysts noted that it is not difficult to verify and correct suspected data errors in the utilization reports issued by large hospitals.

It's [verifying and correcting suspected errors] usually not that difficult. ... It's just getting ahold of the right person and saying this looks funny, or these numbers don't match, can you explain to me why they don't.

Another analyst noted that this can be more difficult when interacting with smaller hospitals.

With a small community hospital, ... for them to go back and check it may be a little more involved than say for a large organization.

Another analyst noted that verification and correction can also be time-consuming when dealing with small municipalities.

In dealing with some of the smaller municipal issues, it may take them a day or two to track down the information and get back to me.

Two of the municipal bond analysts noted that they do not always correct detected data errors. In some cases, the data is simply discarded if it cannot be easily corrected.

If I can't get the information I feel I need to analyze the securities appropriately, we won't mess with it.

In other cases when suspected data errors cannot be corrected, the municipal bond analysts may provide the data containing a suspected error to a bond trader in their organization and tell the trader that the data may be incorrect.

Base Rate of Errors in Data

Table 1 summarizes the estimates of the rate of errors in data given by the municipal bond analysts.

Each municipal bond analyst was asked to estimate the rate of serious and trivial data errors in the data they regularly use. Before the estimates were requested, the interviewee was asked to list the types of data that he or she regularly uses. This list was used to request the base rate estimates. Thus, the types of reports (e.g., new offering statements, audited financial statements) to which the estimates apply vary from interviewee to interviewee. The estimates shown in Table 1 should be interpreted as the percent of each type of report believed to contain at least one data error. For example, the first interviewee shown in Table 1 estimated that 7 to 8% of the new offering statements he uses contain a serious data error and that 12 to 15% of the new offering statements he uses contain a trivial data error.

Error Detection Goals

The municipal bond analysts tend to assume that unaudited data may be incorrect. They appear to view checking unaudited data for errors as a component of their jobs.

I always go into it assuming that there might be an error.

Table 1: Base rate estimates

	Serious Data Errors	Trivial Data Errors
Interviewee #1	7-8% of new offering statements 5-6% of hospital utilization reports 3-4% of audited financial statements	12-15% of new offering statements 12% of hospital utilization reports 7-8% of audited financial statements
Interviewee #2	8% of reports for board of directors 2-3% of prospectuses	25-33% of reports for board of directors 10% of prospectuses
Interviewee #3	0-2% of new offering statements 0-10% of audited financial statements 5% of published mortgage reports 2-3% of published municipal reports	20-40% of new offering statements 10-20% of audited financial statements 10-20% of published mortgage reports 10-20% of published municipal reports
Interviewee #4	Almost 0% of audited financial statements Almost 0% of interim financial reports Almost 0% of pricing reports 0% of internally created reports	Unable to estimate trivial errors in audited financial statements. Almost 0% of interim financial reports Almost 0% of pricing reports 0% of internally created reports
Interviewee #5	7% of unaudited loan portfolio reports 2-3% of detailed loan reports	10% of unaudited loan portfolio reports Stated that all errors in the detailed loan reports are serious

In contrast, the municipal bond analysts tend to assume that audited financial statements are free of errors, especially when the statements have been audited by large, well-known accounting firms.

You assume that since it's audited, that it's right ... especially if it was done by a reputable firm.

If it's an audit from a Big Six accounting firm, I'm not going to be looking real hard for errors.

I have a lot more faith in audited reports than in anything else.

DISCUSSION AND CONCLUSION

The earlier field study of error detection and correction by actuaries (Klein, 1997) and the present study present interesting similarities and differences. In both cases, all of the users interviewed reported specific incidents in which they had detected errors in data. Thus the study of the municipal bond analysts provides additional support for the contention that the detection of data errors by users is not an isolated organizational phenomenon occurring only in very limited circumstances. These findings provide a challenge to earlier research suggesting that users of information systems do not find data errors (e.g., Davis et al., 1967; Laudon, 1986; Ricketts, 1990). The municipal bond analysts were also found to detect data errors using very similar strategies to those found in the study of the actuaries. Both groups of users report finding errors when their expectations are violated, and both groups report that the amount of effort devoted to error detection is influenced by the source of data. This suggests that successful error detection strategies are similar across professions and that useful training interventions based on these strategies might be developed.

Despite the similarities in overall reports of error detection and in reported detection strategies, two differences emerge from a comparison of the findings of the studies of the actuaries and the municipal bond analysts. First, the municipal bond analysts assume that unaudited reports may contain data errors but that audited reports are free of errors. This assumption was not found in the study of the actuaries, who, in general, work with unaudited data. Second, a difference in user reactions to data errors was found. While the municipal bond analysts make efforts to verify and correct suspected errors, some inaccurate data is simply discarded if it cannot be easily corrected. Rather than struggling to correct the data or using bad data, the municipal bond analysts simply decide to not buy the affected bond and "move on to the next (bond) issue." In contrast, the actuaries cannot typically decide to stop working for a client who is supplying inaccurate data. Instead, the actuaries tend to bring the client's data into their own databases and correct inaccurate data. Occasionally, when the actuaries are unable to get inaccurate data corrected, they will use the bad data and issue reports along with a disclaimer about the quality of the underlying data.

Users of information systems and information system managers are understandably interested in minimizing the impact of data errors on business processes and decision making. The following guidelines are suggested by this study.

1. Information system managers should not assume that users are incapable of or unwilling to detect and correct errors in data. While efforts to automatically validate data are certainly worthwhile, it an exaggeration to say that "MIS management had better not rely on users to detect errors in computer outputs" and that it is necessary to engage in "extremely careful validity testing of programs before they are turned over to users" ("Executive overview," 1990).
2. Information system managers should recognize that users of information systems detect errors in data. Mechanisms to encourage users to report data errors to information system personnel responsible for supporting a system should be implemented and efforts to identify the types of errors that are found should be pursued. Automated data validation procedures should be modified to detect and correct these newly identified types of data errors as appropriate.
3. Managers interested in motivating employees to check for data errors should pay particular attention to organizational incentives that reward or penalize efforts to detect errors and should teach users that finding data errors is part of their jobs. This guideline is supported by the present study as well as by the findings of prior experimental research (Klein et al., 1997).
4. User training should include instruction about error detection strategies. Users should be encouraged to compare data values with their prior expectations about those data values, to review changes in periodic reports over time, and to consider the reliability of the sources of data with which they work.
5. Information system managers should be cautious about claiming that the data provided by an information system has been "audited." Claims that an information system provides perfect data may lead users to behave just as the municipal bond analysts did with audited financial statements. That is, users

may fail to be vigilant about the possibility of data errors. Prior experimental research shows that users who are very capable of finding data errors will fail to do so when they believe that looking for errors is not a part of their job responsibilities (Klein et al., 1997). Users who have been told that they are working with data provided by a perfect information system may be especially prone to behaving as though finding data errors is not part of their job.

6. Users of audited information should carefully examine their assumptions about this information. While it is probably reasonable to assume that audited information is more accurate than unaudited information, audited information is not necessarily free of errors and failure to recognize this can lead to costly mistakes.

The results of this study suggest that users of information systems can be effective in detecting data errors and that future research replicating and building on these findings is worthwhile. Research studies examining error detection in other professional domains and studies examining the outcomes of organizational efforts to implement the guidelines outlined above are suggested.

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Chapter XVII

An Analysis of Academic Research Productivity of Information Systems Faculty

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Why are some faculty members more productive than others in academic research? We constructed a number of hypotheses about faculty research productivity based on the life-cycle model of academic research and previous studies. Tests were conducted using data collected via a national survey of information systems (IS) faculty. The results show that while there are only two significant factors contributing positively to the research productivity: the time allocated to research activity and the existence of IS doctoral programs, many other factors appear to have significant adverse effect on research productivity, such as the number of years on faculty, the teaching load when exceeding 11 hours weekly, and non-IS, nonacademic employment experience. The results also suggest that some of the commonly proposed influential factors, such as tenure status, academic rank, school type, as well as IS-related employment experience, have no significant effect at all. The implications of these findings and the limitations of the study are also discussed.

INTRODUCTION

What makes a faculty member more productive in academic research? This is a question of great interest to many tenure-earning and tenured faculty members in academic institutions where faculty performance is evaluated heavily based on research productivity. Productive faculty not only further the knowledge in their professional fields by integrating their findings with those of others via scholarly publications disseminated around the world, they also bring visibility and prestige to themselves and their affiliated institutions, which in turn attracts research grants and more qualified faculty and graduate students (Grover, Segars & Simons, 1992; Levitan & Ray, 1992). Recent studies have also found significant financial incentives for research productivity (Gill, 2001). Because of this, academic institutions are increasingly emphasizing research productivity when evaluating tenure, merit, funding, and salary decisions (Im & Hartman, 1997; Lane, Ray & Glennon, 1990; Levitan & Ray).

As a consequence, it is no surprise to see a growing interest in studying the factors affecting research productivity of individual faculty members as well as institutions (e.g., Niemi, 1988; Lane et al., 1990; Levitan & Ray, 1992; Grover et al., 1992; Hancock, Lane, Ray & Glennon, 1992). Two distinctive research approaches can be identified in the literature of research productivity. One approach examines the collective characteristics of all academic researchers by focusing on the motivation of research, as represented by the life-cycle model (Diamond, 1986; Goodwin and Sauer, 1995; Levin and Stephan, 1991). This model posits that research productivity of a researcher is determined by the interaction of investment motivation and consumption motivation modulated by the process of aging and career maturity. The other approach emphasizes the effects of institutional and personal characteristics on the research productivity, such as teaching load, time management, and tenure status (Hancock et al., 1992; Lane et al., 1990; Levitan and Ray, 1992).

Although these studies have significantly improved our understanding of academic research productivity, the findings are often inconsistent, sometimes even conflicting, depending upon the research approach undertaken and the academic disciplines being studied. In this study, we examine the institutional and personal factors affecting the research productivity of information systems (IS) faculty in the United States based on the results of a national survey. Our data and test model show that factors influencing research productivity of junior and senior IS faculty members differ although many factors, such as teaching load and time allocation for teaching, research, and service, are common to both groups. We found that prior IS-related employment experience shows significant positive correlation with research productivity of junior faculty members but has no relationship to that of the senior faculty. On the other hand, we found that the affiliation with an IS program that offers a doctoral degree is significantly positively correlated with the research productivity of senior faculty members but has no apparent effect on that of the junior faculty members. These findings, augmenting previous ones, should help administrators and faculty members alike make informed decisions in evaluating performance, managing time, and balancing teaching, research, and service loads.

REVIEW OF RESEARCH PRODUCTIVITY

As higher education institutions compete with each other in getting funding for research and teaching programs and attracting quality faculty and students, it has become increasingly important for academics to be more productive in their research fields. Being classified as a "research university" is often perceived as an indication of quality programs, faculty, and students. Very often such classification is based on the research productivity of faculty members or specific programs of a university. In the area of information systems, there have been regular publications comparing the statistics of faculty research productivity of various IS programs in this country (Lending & Wetherbe, 1992; Swanson & Ramiller, 1993; Vogel & Wetherbe, 1984). Grover et al. (1992), for instance, studied the publications by IS faculty members of more than 190 institutions in "core" MIS journals. The top 50 institutions were ranked based on a weighted page count of articles published by their IS faculty. The study, however, did not provide any analysis of why these institutions achieve higher research productivity and if they share any common characteristics that contributed to the high productivity.

There are many reasons why academic institutions want to be ranked high in these types of studies. Prestige is one thing, but enhanced ability to attract funding for various researching and teaching programs from public and private sources may be even more important. To achieve sustained high productivity, an institution can either keep hiring productive faculty members for their programs, which is often impractical due to high cost, or try to identify the factors that most significantly influence the productivity of faculty members. It is the second issue that is the primary interest of this study: What factors make a faculty member more productive? And closely related to the first question, what can an institution do to help its faculty members to be productive?

One of the well-established theories of research productivity is the life-cycle model, which posits that the interaction between two major factors dictates the behavior of an academic researcher, modulated by the process of natural aging: investment-motivated research and consumption-motivated research (Diamond, 1986; Levin & Stephan, 1991). The investment hypothesis states that an individual engages in research because of the perceived significant future financial reward for the research activity. The consumption hypothesis stresses an individual's fascination with research and the satisfaction associated with solving research puzzles. The life-cycle model suggests that early in the career, the strong investment incentive for research complements a researcher's puzzle-solving urge, resulting in an initial surge in research productivity. But as the researcher ages and the present value of the investment declines, they become less productive.

The life-cycle model is appealing in explaining aggregated productivity data across institutions. But it fails to address individual and institutional differences. It is not unusual for some individuals to remain productive throughout their careers, while others quickly drop out of the race after a promising start. Goodwin and Sauer (1995) studied 140 tenured economic faculty members in seven research-oriented academic departments. They found that in general the research productivity of individual researchers follows the basic pattern of the life-cycle model: the productivity rises sharply in the initial stages of a career, peaks at the time of tenure review, and then begins a decline. However, the rate of the decline is slower than that predicted by the life-cycle model. Several factors were examined in explaining the different declining patterns. It was found that the post-peak decline in productivity is quite modest for the high publication rate group compared to the low publication rate group, which is consistent with the hypothesis that early recognition provides the so-called reputation capital, which yields positive returns in subsequent periods. Career choices of individual researchers after tenure also were found to significantly affect the decline patterns: those who took academic administrative positions, such as department head, dean, or journal editor, showed a significant drop in productivity compared to their colleagues. The study also found a strong tendency for institutional productivity equalization: those who graduated from the top economics Ph.D. programs were significantly more productive than others, and faculty in one institution tended to be more productive then those of another across the board.

While these findings are informative, they offer few insights for individual faculty members and administrators seeking to improve research productivity in a given institutional environment. Levitan and Ray (1992) provided a more detailed description of the personal and institutional characteristics affecting research productivity of academic accountants. They found that the most important factor in research productivity is the ability to effectively manage time. They suggested that individuals who allocate longer hours to research can seemingly increase their research productivity, and that institutions, by providing graduate assistants and reducing teaching and administrative duties for their faculty, can raise their aggregate research productivity.

Although most findings in later studies are in general agreement with the life-cycle model, the effect of tenure on research productivity is an area where many inconsistencies have surfaced. According to the life-cycle model, after a faculty member receives tenure, the investment motivation should decline significantly, resulting in a drop in research productivity. However, in studying the research productivity of academic accountants, Levitan and Ray (1992) found that more members of the productive group are tenured than the ones in the control group, and their self-reported productivity has increased or at least remained the same since tenure. Even stronger evidence is provided by the study of Hancock et al. (1992), in which 128 authors who published in management science and operations research were surveyed to ascertain what individual and institutional factors correlate with their productivity. They found that the research productivity of the high publishing group (13 or more articles in a 5-year period) has actually increased since tenure while that of the low publishing group (7 or less articles in the 5-year period) has remained about the same. It was hypothesized that tenure no longer diminishes the tangible rewards to be gained through publication because the rapid rise in academic salaries maintains an ongoing pressure on faculty members to stay marketable. Further, by the time of tenure, a faculty member has prepared courses, defined a research stream, and honed the skills to follow it. These conditions provide the newly tenured faculty member both motive and opportunity to maintain productivity at no less than pre-tenure levels (Hancock et al., 1992).

RESEARCH HYPOTHESES

Summarizing the findings of previous studies of academic research productivity, one can conclude that many factors may have contributed to the research productivity: age, education, tenure, time management ability, institutional support, financial incentive, mobility, etc. Furthermore, it has been shown that differences in scientific disciplines may affect the productivity patterns of academics (Levin & Stephan, 1991). With almost all of the previous studies of research productivity being discipline-specific, it is only natural to ask which, if any, of these factors are more pronounced in the information systems discipline?

As one of the fastest growing academic fields, the IS discipline poses many unique and demanding challenges to its faculty members. For example, not only do IS faculty members have to conduct scholarly research while keeping up with the requirement for teaching and service duties, they also need to constantly upgrade themselves with new knowledge and skills demanded by the rapidly changing information technology (IT) environment and IS management practices. This need to upgrade skills competes directly with research activity for the precious time that remains after teaching and service duties have been fulfilled. Thus the unique challenge of the IS environment may lead to the consequences that do not exist or are less pronounced in other disciplines on which previous studies of research productivity were based.

For example, consider the effect of tenure and seniority on research productivity. Naturally, all the arguments of the life-cycle model that apply to other fields also apply to IS faculty members, suggesting that productivity should decline with tenure and seniority. Beyond the life-cycle model, however, the fast-changing IT environment may favor the productivity of junior faculty members over senior faculty. We argue, for example, that the newly graduated doctoral candidates are likely to be better technically equipped for doing research on current IS issues than faculty members who graduated many years earlier for two main reasons. First, IS as a discipline has matured with established theoretical foundations and doctoral programs designed to provide rigorous training in research methodologies and theories. Second, doctoral candidates are more likely to be exposed to the advanced information technologies in their research and teaching. As a consequence, junior faculty members would need to spend less time upgrading their skills and knowledge than senior members, resulting in more time for research activities. These arguments lead to the following hypotheses:

Hypothesis 1a: There is a negative relationship between tenure and research productivity. In general, the tenure-earning faculty members are likely to be more productive than tenured faculty members.

Hypothesis 1b: There is a negative relationship between years on faculty and research productivity. In general, junior faculty members are likely to be more productive than senior faculty members.

Next we consider the effect of time management on research productivity. The time management of faculty members is limited by three factors: teaching and service load, availability of graduate assistants, and nonacademic related activities, such as consulting and outside employment. It can be argued that the IS faculty member in the institutions where graduate programs (master's and doctorate) are offered have a better chance of getting graduate assistants and are more likely to have a lower teaching load due to the research orientation of the programs. On the other hand, they also tend to have more responsibility for service-related workload, such as serving on dissertation committees and supervising graduate theses. Thus it is not automatic that a lower teaching load and a graduate program lead to more time for research activity and higher research productivity. In balance, however, we would expect that having graduate student assistants and working with doctoral students should have a positive effect on faculty research productivity. This is because, in most cases, a faculty member who supervises graduate and doctoral students can concentrate his or her time on the more critical activities leading toward publication and leave the nonproductive but necessary activities to the student assistants. Coauthorship with doctoral students may also contribute significantly to the supervising faculty member's article count. This line of reasoning leads to the following hypotheses:

Hypothesis 2a: There is a positive correlation between research productivity and time allocated for research activity. The faculty members who allocate more time for research activity tend to be more productive than otherwise.

Hypothesis 2b: There is a positive correlation between research productivity and the affiliation with graduate programs. The faculty members in the institutions where graduate IS programs are offered are more productive than those in the undergraduate only institutions.

Another factor of time management is the teaching load. It has been suggested that research productivity may be inversely related to the teaching load (Hancock et al., 1992), which is intuitively appealing. We add the hypothesis about the relationship between teaching load and research productivity here as a check of validity of our data sets and models to be tested:

Hypothesis 2c: There is a negative correlation between research productivity and the teaching load. The faculty members who have the lighter teaching loads are more productive than those who have heavier teaching loads.

Finally, we consider the effect of nonacademic employment experience on research productivity of faculty members. As an applied discipline, the majority of the IS research focuses on the practical issues of IT usage and management. It is reasonable to argue that real world IS-related employment experience would enhance an individual's ability to conduct academic research. On the other hand, we can expect that non-IS-related employment experience may have little effect for obvious reasons. This leads to the following hypotheses:

Hypothesis 3a: There is no correlation between research productivity and the non-IS, non-academic employment experience before becoming an IS faculty member. The faculty members who have more years of such employment are no more productive than those who have fewer or none.

Hypothesis 3b: There is a positive relationship between research productivity and the number of years of IS-related employment before becoming an IS faculty member. The faculty members who have more years of IS-related employment are more productive than those who have fewer or none.

DATA AND METHOD

The Survey

The data set for this study was collected via a survey[1] conducted as a joint project of the authors and a sponsoring company that specializes in undergraduate education products. The immediate objectives of this survey were to advance the state of knowledge of IS education in the United States. It was also intended to provide information about existing IS programs for a biannual reassessment of the undergraduate computer information systems major being conducted at the authors' university. The questions in the survey were designed to help address a number of questions regarding the overall characteristics of IS programs and faculty in the United States. Among the 90 questions, we asked each respondent to indicate how many refereed academic journal articles she or he had published during the last 5 years. This number, combined with information collected in other questions, was used to assess the factors that influence the research productivity of IS faculty.

The survey instrument was mailed in late October 1996 to over 2,000 IS faculty members in 442 different U.S. higher education institutions listed in the Management Information Systems Research Center (MISRC) directory. Responses were accepted through January 15, 1997. By the cutoff date, there were 240 usable responses received, representing a 12% individual response rate. Viewed in terms of institutions, the rate was much higher: surveys were returned from faculty at 193 different institutions, a 44% institutional response rate.

Most of the respondents were affiliated with traditional 4-year colleges and universities with advanced degree programs: about 84% of the responding institutions offered graduate level programs, with 46% of them offering doctoral level degrees, and 38% offering master's level degrees. More than 85% of the responding faculty members were affiliated with 4-year graduate-degree-granting institutions. Among them, over 90% were professors, associate professors, and assistant professors; the rest were adjunct faculty and instructors. Since we are interested only in the factors related to academic research productivity, and adjunct faculty and instructors are usually not required to do research, their responses were deleted from the sample. In addition, incomplete responses were deleted. The final sample consists of 172 responses from individual faculty members. The overall characteristics of these faculty members and their institutions are summarized in Table 1.

The Research Model

Previous studies have shown that faculty research productivity is a result of the interaction among many endogenous and exogenous variables, ranging from individual personal characteristics, academic discipline, and educational experiences to institutional characteristics, teaching, research and service assignments, and employment experiences. By focusing on one specific academic discipline (i.e., IS), many of the variables could be eliminated. As a further simplification, we set our research objective to be identifying the variables that may have significant effect on research productivity, rather than quantifying such effects on the productivity or testing any specific theories of research productivity. For those reasons, we chose a general linear regression model as the most appropriate tool for the analysis, i.e.:

$$Y = \beta_0 + \sum_{i=1}^{n} \beta_i X_i$$

Where Y is the dependent variable, X_i (i = 1, 2, …n) are the independent variables, and β_i (i = 0, 1, 2, … n) are the regression coefficients.

In establishing the model, we chose the self-reported average number of articles published in refereed academic journals each year (averaged over the last 5 years) as the indicator of faculty research productivity. Thirteen independent variables were identified based on the findings of previous studies as well as our research hypotheses. However, preliminary tests on collinearity among the variables resulted in the elimination of three variables. As a result, 10 independent variables were used in the final model. The detailed definitions and descriptions of these variables are presented in Table 2.

*Table 1: Characteristics of the responding institutions**

Institution	Respondents		Professor		Associate Professor		Assistant Professor	
	Count	%	Count	%	Count	%	Count	%
4YwD	92	53	28	43	41	63	23	55
4YwM	65	38	33	51	19	29	13	31
4YwU	15	9	4	6	5	8	6	14
Overall	172	100	65	100	65	100	42	100

* 4YwD, 4YwM, 4YwU represent 4-year college/university with highest degree offered being doctoral, master's, and bachelor's, respectively.

RESULTS

IS Faculty Research Productivity

To better describe the overall characteristics of the research productivity of IS faculty, the total number of articles published and the annual rate of publication are summarized based on faculty academic rank, teaching load, tenure status, and non-academic IS employment experience. These results are presented in Tables 3a through 3d. It should be noted, however, that since many respondents had been at faculty positions for less than 5 years, the total number of articles over the last 5 years might not be a reliable measure for productivity. It is included in the tables only as a reference. The annual rate of publication, which was the article count divided by the smaller of 5 and years of academic employment, was therefore viewed to be a more suitable indicator of research productivity.

In terms of average annual rate of publication, the professor group seems to have the highest research productivity with 1.22 articles per year, followed by the

Table 2: Definition and coding scheme for independent variables

VARIABLE	TYPE	DESCRIPTION	CODING SCHEME
X_1	Metric	Number of years on IS faculty	1, 2, 3, …
X_2	Metric	Number of years of non-IS, nonacademic full-time employment	1, 2, 3, …
X_3	Metric	Number of years of IS-related nonacademic full-time employment	1, 2, 3, …
X_4, X_5, X_6	Metric	Percentages of time allocated for teaching, research, and academic services[2]	0.1, 0.8, 0.2, …
X_7, X_8	Dummy	Variables for school type	(0, 0) for 4YwU, (1, 0) for 4YwM, and (0, 1) for 4YwD.
X_9, X_{10}, X_{11}	Dummy	Variables for weekly teaching load	(0, 0, 0) for < 5 hours, (1, 0, 0) for 5~7 hours, (0, 1, 0) for 8~11 hours, (0, 0, 1) for 12~14 hours[3].
X_{12}, X_{13}	Dummy	Variables for academic rank	(0, 0) for assistant professor, (1, 0) for associate professor, and (0, 1) for professor[4].
X_{14}	Dummy	Variable for tenure status	0 for tenure-earning, and 1 for tenured.
X_{15}	Dummy	Variable for terminal degree	0 for master's and 1 for doctorate.
X_{16}~X_{23}	Dummy	Variables for IS programs offered in a university or college	Each variable represents the existence of undergraduate IS major (X_{16}), IS minor (X_{17}), undergraduate IS survey (X_{18}), IS master's (X_{19}), IS track in MBA (X_{20}), graduate IS survey (X_{21}), IS doctorate (X_{22}), and executive IS programs (X_{23}).

Table 3a: IS faculty research productivity by academic rank

ACADEMIC RANK	REFEREED ARTICLES PUBLISHED (Over Last Five Years)			RESEARCH PRODUCTIVITY (Annual Rate of Publication)		
	Median	μ	σ	Median	μ	σ
Professor	3.0	6.108	6.940	0.600	1.222	1.388
Associate	4.0	5.123	4.419	0.800	1.045	0.921
Assistant	3.0	4.071	3.195	0.900	0.942	0.620
Overall	4.0	5.238	5.372	0.800	1.087	1.078

Table 3b: IS faculty research productivity by teaching load levels

WEEKLY TEACHING HOURS	REFEREED ARTICLES PUBLISHED (Over Last Five Years)			RESEARCH PRODUCTIVITY (Annual Rate of Publication)		
	Median	μ	σ	Median	μ	σ
5-7	6.000	8.065	6.591	1.200	1.685	1.306
8-11	3.000	4.604	4.511	0.775	0.949	0.901
12-14	2.000	2.071	2.107	0.400	0.438	0.437

Table 3c: IS faculty research productivity by tenure status

TENURE STATUS	REFEREED ARTICLES PUBLISHED (Over Last Five Years)			RESEARCH PRODUCTIVITY (Annual Rate of Publication)		
	Median	μ	σ	Median	μ	σ
Tenure-earning	3.000	4.476	3.387	1.000	1.055	0.720
Tenured	4.000	5.485	5.862	0.800	1.097	1.172

Table 3d: IS faculty research productivity by employment experience

IS-RELATED EMPLOYMENT	REFEREED ARTICLES PUBLISHED (Over Last Five Years)			RESEARCH PRODUCTIVITY (Annual Rate of Publication)		
	Median	μ	σ	Median	μ	σ
Faculty w/ IS	3.000	5.661	5.516	0.900	1.180	1.110
Faculty w/o IS	4.000	4.450	5.044	0.600	0.913	1.002

associate professors with 1.045, and then the assistant professors with 0.942. Overall, an IS faculty member publishes one article per year in refereed academic journals, with a standard deviation of one article. The faculty members with the lowest teaching load (5-7 hours per week) enjoy the highest research productivity at 1.68 articles per year, which is almost double the rate of those with 8-11 teaching hours and quadruple the rate of those who teach 12-14 hours per week. Tenure status and non-academic IS employment experience seem to have minimal impact on the research productivity, as show in Tables 3c and 3d.

The average rate of publication, however, may have not depicted a fair comparison of the research productivity between different groups due to the presence of large variances. It can be seen that in all cases the standard deviations are almost as large as the averages, indicating a highly heterogeneous sample population in terms of research productivity. Under such circumstance, the median rate of publication may be a better alternative. From that point of view, assistant professors have the highest median publication rate at 0.9 articles per year, followed by the associate professors at 0.8, which is equal to the median of all faculty members, and the professor group has the lowest median rate at 0.6 articles per year. This is completely the opposite of the order based on the averages, largely due to the fact that the professor group has the highest variance and the assistant professor group has the smallest variance. Thus the true effect of academic rank could not be determined by simple statistics.

On the other hand, the strong effect of teaching load was not blurred by the large variances: the order of productivity based on the median rate of publication is the same as the one based on the average rate of publication. In the cases of tenure status and employment experience, the median rates of publication suggest that tenure-earning faculty members are slightly more productive than tenured faculty members, which is consistent with the result based on academic ranks. The effect of non-academic IS employment is also more pronounced in terms of median rate than it is of the average: the faculty with prior non-academic IS employment experience are about 50% more productive than those without such experiences.

Although the average and median rates of publication have presented an overall picture of IS faculty research productivity, the inferences based on these statistics are also conflicting and confusing as the result of large variances in the data sample. This is clearly demonstrated by the results of ANOVA performed on these groups, as shown in Table 4.

It is therefore obvious that more sophisticated statistical techniques need to be used in order to assess more accurately the effects of many individual factors. In the next section, we use the linear regression model defined in the previous section to evaluate such effects.

The Influential Factors

To determine the individual effect of the 13 independent variables, as defined in Table 2, on the research productivity, the linear regression model was first estimated using the 172 observations in our data set. The F statistic of the model is 4.580, significant at $p<0.001$ level, indicating a good fit between the observed data and the model. The R^2 is 0.416 and R^2-adj. is 0.325, indicating that about one third of the variance of the dependent variable, Y, the average annual rate of publication,

Table 4: Summary of single factor ANOVA tests

ANOVA FACTOR	REFEREED ARTICLES PUBLISHED (Over Last Five Years)			RESEARCH PRODUCTIVITY (Annual Rate of Publication)		
	F	p (α=0.05)	$H_0: \mu 1=\mu 2=\ldots$	F	p (α=0.05)	$H_0: \mu 1=\mu 2=\ldots$
Academic Rank	1.876	0.156	Accept	0.933	0.395	Accept
Teaching Load	14.268	0.000	Reject	15.731	0.000	Reject
Tenure Status	1.119	0.292	Accept	0.047	0.827	Accept
IS Employment	1.996	0.159	Accept	2.403	0.123	Accept

can be explained by the variations of the independent variables. Giving the large sample size and the great heterogeneity of the respondents, this R^2-adj. should be considered as satisfactory.

The estimated values of the regression coefficients are presented in Table 5. Note that we used the indicator coding scheme for the dummy variables (for details, see Hair, Anderson, Tatham & Black, 1995, p. 109). As a result, the effects of the dummy variables are relative to the comparison group (i.e., the group with all zero values) for each set of dummies. For instance, the effect of teaching load on the research productivity is relative to the comparison group that has a teaching load less than 5 hours per week, coded as $X_9 = X_{10} = X_{11} = 0$. For coding schemes of the other dummy variables, refer to Table 2.

Since the dependent variable, the rate of publication, is calculated using the self-reported number of refereed articles in the last 5 years divided by X_1 if $X_1 < 5$ or by 5 if $X_1 \geq 5$, it may be inflated if a respondent had published some articles as a doctoral candidate and served less than 5 years on the faculty. To avoid this potential problem and to assess the impact of this factor, we constructed another data set with only the responses from the faculty members who have been on the faculty for 6 or more years. Of the 172 responses, 143 responses meet this criterion. As a result, this data set consists of virtually only the responses from senior and tenured faculty members. With this new data set, the regression F statistic is 4.687 (significant at $p<0.001$), the R^2 is 0.475 and R^2-adj. is 0.374. Comparing to the full data set, the goodness of fit of the model has been improved about 15%. This small improvement may be attributed to the more homogeneous data set. The estimated regression coefficients using this new data set are presented in Table 6.

DISCUSSIONS

Does Tenure Affect Faculty Research Productivity?

The regression results based on both data sets show that there is no significant correlation between tenure status and research productivity. The regression coefficients for the tenure status variable, X_{14}, in both regression models are not significantly different from zero. Thus Hypothesis 1a is not supported by our data. This is inconsistent with the findings of many previous studies of other academic fields (Goodwin & Sauer, 1995; Levin & Stephan, 1991), especially the prediction of the life-cycle model. It is also inconsistent with the findings of Lane et al. (1990) on statisticians, Levitan and Ray (1991) on academic accountants, and Hancock et al. (1992) on management science researchers, which suggest that tenured faculty members are more productive than those without tenure.

Are Junior Faculty Members More Productive Than Senior Ones?

The life-cycle model predicts that faculty research productivity will decline as an individual's academic experience increases, mostly due to the reduction of

Table 5: Result of regression with all faculty

Variable	Description	DF	β_I	SE	$t : (\beta_I = 0)$	$p > \lvert T \rvert$
X0	Intercept	1	2.723	0.940	2.895	0.004 ***
X1	Years on IS faculty	1	-0.025	0.013	-2.009	0.046 **
X2	Years of non-IS, nonacademic	1	-0.047	0.023	-2.026	0.045 **
X3	Years of IS-related nonacademic	1	0.003	0.013	0.262	0.794
X4	Time for teaching	1	-0.989	0.435	-2.274	0.024 **
X5	Time for research	1	1.129	0.593	1.904	0.059 *
X6	Time for services	1	-1.813	0.708	-2.559	0.012 **
X7	Master's program	1	-0.315	0.280	-1.123	0.263
X8	Doctoral program	1	-0.170	0.290	-0.585	0.559
X9	Teaching 5-7 hours	1	-0.752	0.665	-1.131	0.260
X10	Teaching 8-11 hours	1	-1.102	0.673	-1.639	0.103
X11	Teaching 12-14 hours	1	-1.445	0.702	-2.060	0.041 **
X12	Associate professor	1	0.326	0.290	1.128	0.261
X13	Full professor	1	0.548	0.315	1.739	0.084 *
X14	With tenure	1	0.115	0.301	0.384	0.702
X15	Doctorate degree	1	0.178	0.349	0.511	0.610
X16	IS major	1	0.218	0.232	0.938	0.350
X17	IS minor	1	-0.403	0.158	-2.555	0.012 **
X18	IS survey	1	0.092	0.172	0.534	0.594
X19	IS master's	1	-0.071	0.169	-0.422	0.673
X20	IS MBA	1	-0.005	0.154	-0.034	0.973
X21	IS graduate survey	1	-0.091	0.153	-0.601	0.549
X22	IS doctorate	1	0.164	0.209	0.783	0.435
X23	IS executive program	1	0.339	0.222	1.562	0.129

Note: 1) $N = 172$, $F = 4.580$, $p < 0.001$, $R^2 = 0.416$, R^2-adj.$= 0.325$

2) * Significant at $p < 0.1$, **Significant at $p < 0.05$, *** Significant at $p < 0.01$

3) For detailed variable description and coding schemes, see Table 2.

investment motivation. Examining the estimated regression coefficient of variable X_1, the number of years on IS faculty, in Table 5, we can see that X_1 is significantly ($p < 0.05$) negatively ($\beta_1 = -0.025$) correlated with an IS faculty member's research productivity. The decline of investment motivation of senior faculty members is one plausible reason for the inverse correlation. Meanwhile, senior faculty members tend to have more service and administrative responsibilities than junior ones, which may seriously hinder their research productivity. When most of the junior faculty responses are excluded from the data set, as is the case of Table 6, this effect is no longer significant at the $p < 0.05$ level. These results indicate that among the senior faculty members, number of years on faculty has a less significant influence on research productivity. This is consistent with our hypothesis that one major difference between junior and senior faculty members is the investment motivation. Overall, then, we can conclude that Hypothesis 1b is supported by our data.

Table 6: Result of regression with faculty (Years on IS Faculty $X_1 \geq 6$)

Variable	Description	DF	β	SE	t (βI=0)	p >|T]
X0	Intercept	1	2.609	0.996	2.619	0.010 **
X1	Years on IS faculty	1	-0.025	0.015	-1.717	0.089 *
X2	Years of non-IS, nonacademic	1	-0.034	0.028	-1.196	0.234
X3	Years of IS-related nonacademic	1	0.011	0.015	0.764	0.446
X4	Time for teaching	1	-0.977	0.478	-2.045	0.043 **
X5	Time for research	1	1.721	0.655	2.628	0.010 **
X6	Time for services	1	-1.490	0.772	-1.931	0.056 *
X7	Master's program	1	-0.464	0.335	-1.388	0.168
X8	Doctoral program	1	-0.268	0.342	-0.784	0.434
X9	Teaching 5-7 hours	1	-0.646	0.690	-0.937	0.351
X10	Teaching 8-11 hours	1	-1.024	0.696	-1.470	0.144
X11	Teaching 12-14 hours	1	-1.276	0.730	-1.749	0.083 *
X12	Associate professor	1	0.072	0.333	0.215	0.830
X13	Full professor	1	0.323	0.352	0.919	0.360
X14	With tenure	1	0.174	0.340	0.512	0.610
X15	Doctorate degree	1	0.348	0.393	0.885	0.378
X16	IS major	1	0.011	0.290	0.038	0.969
X17	IS minor	1	-0.425	0.177	-2.403	0.018 **
X18	IS survey	1	0.173	0.192	0.901	0.370
X19	IS master's	1	-0.114	0.190	-0.603	0.548
X20	IS MBA	1	-0.051	0.177	-0.288	0.774
X21	IS graduate survey	1	-0.003	0.178	-0.017	0.987
X22	IS doctorate	1	0.416	0.245	1.67	0.092 *
X23	IS executive program	1	0.367	0.269	1.363	0.176

Note: 1) N = 143, F = 4.687, $p < 0.001$, $R^2 = 0.475$, R^2-adj. = 0.374
2) * Significant at $p < 0.1$, **Significant at $p < 0.05$, *** Significant at $p < 0.01$
3) For detailed variable description and coding schemes, see Table 2.

Does Spending More Time on Research Improve Productivity?

One consistent finding of previous studies of research productivity has been that research productivity heavily depends on how much time one spends on research-related activities: productive researchers allocated more time on research activity (Hancock et al., 1992; Lane et al., 1990). The IS faculty data here show more complicated patterns. While the percentage of time allocated for teaching (X_4) shows strong ($p < 0.05$) negative correlation with the research productivity of all faculty members (β_4 = -0.989) and senior faculty members (β_4 = -0.977), the positive effect of time allocated to research (X_5) is more pronounced on senior faculty members (β_5 = 1.721, significant at $p < 0.05$ level) than on all faculty members (β_5 = 1.129, significant at $p < 0.1$ level), and the negative effect of time allocated for services (X_6) is more pronounced on all faculty members (β_6 = -1.813, significant at $p < 0.05$ level) than on senior faculty members (β_6 = -1.490, significant at $p < 0.1$ level). Thus we conclude that, in general, Hypothesis 2a is supported by our data. We should note, however, the differences between the junior and senior faculty members. These may help explain, to a certain degree, why senior faculty members are less productive than the junior faculty. Giving the same teaching load, junior faculty members are likely to have a lighter service load, which alleviates the negative effect of time for services; while senior faculty members are likely to spend less time for research due to heavier service load, which reduces the positive effect of time for research. It is also important to note when interpreting this result, that the faculty member who allocates a higher percentage of time for research does not necessary have a lighter teaching and service load. He or she may simply work more hours than the others in order to achieve higher research productivity while fulfilling the same teaching and service responsibility as others.

Do IS Programs Affect Faculty Research Productivity?

In our model, there are two groups of dummy variables designed to measure the effect of IS programs on faculty research productivity. Variables X_7 and X_8 represent the effect of school types (4YwU, 4YwM, and 4YwD). The regression coefficients of these two variables in both Tables 5 and 6 show that there is no significant correlation between school types and faculty research productivity. However, significant coding error may occur with this type of classification: when a faculty member is affiliated with, for instance, a 4YwD type of university, it is not necessarily true that the IS program also has a doctoral program. For this reason, the second group of variables, X_{16} to X_{23}, may be better indicators of the effects of IS programs. It can be seen that the existence of an IS minor program is strongly ($p<0.05$) negatively ($\beta_{17} = -0.403$ and -0.425) correlated to the research productivity of IS faculty members in both data sets; while the IS doctoral program is marginally ($p <0.1$) positively ($\beta_{22} = 0.416$) correlated to the research productivity only in the second data set, where the responses from junior faculty members have been excluded. Other IS programs, such as undergraduate major, graduate major, or MBA with IS track, have insignificant effect. IS faculty in the schools where only IS minor programs are offered usually get the minimum support and least emphasis on research, which inevitably leads to lower productivity. On the other hand, those faculty members, especially the senior faculty members, in the schools where IS doctoral programs are offered usually get the best support, such as graduate assistants, collaboration and coauthorship with doctoral students, which leads to higher productivity. Thus we conclude that Hypothesis 2b is partially supported: only the affiliation with doctoral programs is positively correlated with the research productivity of senior faculty members.

Does Teaching Load Affect Faculty Research Productivity?

The regression coefficients of X_4 confirm the common sense that teaching load has an adverse effect on research productivity. However, to what degree does teaching load significantly hinder an IS faculty member's research productivity?

Using the three dummy variables, X_9, X_{10}, and X_{11}, representing four levels of teaching loads, the regression model suggests that the negative effect of teaching load on research productivity becomes significant ($p < 0.05$) only when the weekly teaching load exceeds 11 hours. If a faculty member's weekly teaching load is below 11 hours, there is no significant correlation between teaching load and research productivity. Noting that the regression coefficients of the three variables are all large negative values, this result is perhaps more an indication that when the teaching load is too high, the research productivity of even the highly motivated faculty members willing to work extra hours would be severely affected, than that teaching load would not affect faculty research productivity if it is within the 11 hour limit. Thus, in general, Hypothesis 2c is supported by our data.

Does IS-Related Employment Experience Help IS Academic Research?

As an applied scientific discipline, the majority of IS research issues have their roots in the real-world IS environment. We therefore hypothesized that non-IS, nonacademic employment experience should have no significant effect on faculty research productivity, and that the faculty members who have extensive real world IS-related employment experience should be more productive than those who do not. Variables X_2 and X_3 are used to represent such experiences. The results are interesting. First it shows that the IS-related, nonacademic full-time employment experience (X_3) has no relationship with research productivity: the estimated regression coefficients are not different from zero in both full faculty and senior faculty data sets. On the other hand, the results show that non-IS, nonacademic full-time employment experience (X_2) is significantly ($p < 0.05$) negatively ($b_2 = -0.047$) correlated to the research productivity for all faculty members but not for senior faculty members ($b_2 = -0.034$, $p = 0.234$). Thus, the two hypotheses on the effect of employment experiences are not supported by the data.

There are plausible explanations for these seemingly counterintuitive results. The initial negative impact of non-IS, nonacademic employment experience on research productivity can be explained by the fact that faculty members who had extensive nonacademic experience often join academic institutions for the purpose of teaching rather than conducting academic research. However, pure teaching faculty members can rarely survive long in today's higher education institutions. More and more colleges and universities use publication as one of the major criteria for faculty performance evaluation, promotion, and salary decisions. Eventually most faculty members conduct some sort of research, which explains why the negative effect of the non-IS, nonacademic employment experience becomes insignificant when tested using the data of faculty members who have been on the faculty for 6 or more years.

The insignificant effect of IS-related employment experience is possibly accounted for by the fact that people with corporate IS experience are often at low-level positions when they decide to pursue a doctoral degree in the IS field. Our own experience in faculty recruiting over the years suggests that the candidates with IS employment experience often worked at the level of programmers and systems analysts. At these positions, the likely benefits of IS-related employment experience with respect to scholarly research are minimal, if any. In addition, the fast-changing nature of IT and related management issues further diminish the impact of IS-related employment experience on research productivity, given the fact that it normally takes 4 to 5 years of full-time study to get a doctoral degree, which is comparable to the time it takes to introduce an entirely new generation of IT and the related IS research issues.

CONCLUSIONS

In this study we have attempted to identify the set of variables that have the most significant effect on the research productivity of IS faculty members. From the results of both the overall statistics and the results of the linear regression model, we can see that productive IS faculty members come in many shapes and forms. A junior faculty member may be productive due to his or her current technological skills or a strong investment motivation that leads to longer working hours and more time being allocated for research activities. A light service load will be very helpful, too. A senior faculty member may be productive due to favorable teaching loads, opportunities to work with multiple junior faculty members and doctoral students on research projects, or more time for research activities due to fewer new preparations for classes. On the other hand, our findings suggest that the research productivity of an IS faculty member will be adversely affected if he or she is assigned with a weekly teaching load of more than 11 hours, works in a department where no IS major programs are offered, takes on too many academic service responsibilities, or has been on the faculty position for a long time.

There are a few factors that seem to affect only selected groups of faculty members. For instance, non-IS, nonacademic full-time employment experience seems to have a greater negative impact on the research productivity of junior faculty members than senior ones. In contrast, affiliation with an IS program that offers a doctoral program seems to have a greater positive impact on the research productivity of senior faculty members than junior ones.

We also found that some commonly proposed influential factors, such as tenure status, academic rank, and school types, seem to have no significant correlation to faculty research productivity. It implies that an assistant professor working in a business department of a undergraduate university can be as productive as the one working at a major university with doctoral IS programs, as long as she or he is highly motivated, is not overly booked for teaching and service, and is supported by the department for research.

Like any other study relying on survey data, there are potential limitations to this study that might affect the reliability of the data as well as the validity of the statistical results. First, it should be noted that the publication data is self-reported.

It is possible that some of the numbers may be inflated for various reasons. Second, the quality of the academic journals was not considered in this study. We can reasonably assume that articles published in the top-tier IS journals usually take much more effort and longer time cycles than the ones published in the bottom-tier journals. This may explain partially why school type has no apparent effect on faculty research productivity. Previous studies have clearly established the fact that the top IS journals were dominated by the faculty from the top IS programs (Lending & Wetherbe, 1992; Vogel & Wetherbe, 1984).

Finally, there was no control over coauthorship. It is reasonable to assume that it takes more effort and time to publish a sole authored article than to publish multiple coauthored ones. This may explain why full professors have been shown to have the higher research productivity, even though the life-cycle model as well as the factors examined in this study clearly imply that they should have much lower research productivity. Full professors may be more likely to work with multiple junior faculty members and with multiple doctoral students on different research projects that lead to multiple coauthored publications.

With these limitations in mind, we believe that the findings of this study can be helpful to faculty members who want to improve individual research productivity and to the administrators who want to understand the impact of faculty working environment on research productivity. This study may also serve as a basis for future research into the research productivity issue of IS faculty, having highlighted relevant theoretical models and practical issues related to data gatherings.

ENDNOTES

1 The complete survey instrument is available upon request from the authors.

2 In the questionnaire, respondents were asked to provide information about percentage of time allocated for eight activities, which were then combined into four categories: teaching, research, academic service, and outside activity. Since all four categories add to 100%, only the first three are used in the model.

3 No respondents in the sample reported higher than 14 hour weekly teaching load.

4 We are mostly interested in understanding the effect of academic ranks on research productivity. The responses of adjunct and instructors are not included in the sample.

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Chapter XVIII

Integrating Knowledge Process and System Design for Naval Battle Groups

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INTRODUCTION

Interest in and attention to knowledge management have exploded recently. But integration of knowledge process design with information system design has long been missing from the corresponding literature and practice. The research described in this paper builds upon recent work focused on knowledge management and system design from three integrated perspectives: 1) reengineering process innovation, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. With this work, we now have an integrated framework for knowledge process and system design that covers the gamut of design considerations from the enterprise process in the large, through alternative classes of knowledge in the middle, and on to specific systems in the detail. We illustrate the use and utility of the approach through an extreme enterprise example addressing Navy carrier battle groups in operational theaters, which addresses many factors widely considered important in the knowledge management environment. Using this integrated methodology, the reader can see how to identify, select, compose and integrate the many component applications and technologies required for effective knowledge system and process design.

KNOWLEDGE MANAGEMENT AND SYSTEM DESIGN

The power of knowledge has long been ascribed to successful individuals in the organization. But today it is recognized and pursued at the enterprise level through a practice known as knowledge management (Davenport & Prusak, 1998). According to recent surveys of the literature (Nissen, Kamel & Sengupta, 2000), interest in and attention to knowledge management (KM) have exploded recently, and many prominent technology firms now depend upon knowledge-work processes to compete through innovation more than production and service (McCartney, 1998).

Even a quick look through the trade press shows information technology (IT) lies at the center of most knowledge management projects today. But IT employed to enable knowledge work appears to target data and information, as opposed to knowledge itself (Ruggles, 1998). For instance, extant IT used to support knowledge management is limited primarily to conventional database management systems (DBMS), data warehouses and mining tools (DW/DM), intranets/extranets and groupware (O'Leary, 1998). Arguably, just looking at the word "data" in the names of many "knowledge management tools" (e.g., DBMS, DW/DM), we are not even working at the level of information, much less knowledge.

We feel this contributes to difficulties experienced with knowledge management to date. Knowledge is noted as being quite distinct from data and information (cf. Davenport, DeLong & Beers, 1998; Nonaka, 1994; Teece, 1998). And it is naïve to expect systems and tools developed to support data and information flows to prove useful for supporting the flow of knowledge through the enterprise. For purposes of this article, we draw from the literature and operationalize knowledge in terms of the actions it enables (e.g., making good decisions, effecting appropriate behaviors).

The research described in this paper builds upon recent work (Nissen et al., 2000; Oxendine & Nissen, 2001) focused on knowledge management and system design from three integrated perspectives: 1) reengineering process innovation, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. This recent work developed an integrated framework for knowledge process and system design. Such a framework covers the gamut of design considerations from the enterprise process in the large, through alternative classes of knowledge in the middle, and on to specific systems in the detail. In this paper, we demonstrate the application of this framework for integrated process and system design using a knowledge-intensive process example from the U.S. Navy: battle group theater transition. This method has been successfully applied to other maritime processes (Nissen & Espino, 2000), and its application in this paper builds on the fieldwork performed by Oxendine (2000).

In the sections that follow, we provide some background information drawn from the knowledge management literature. We then summarize the prior work to describe the framework for integrating knowledge process and system design. We subsequently employ this design approach through a specific Navy battle group example. This example addresses many factors widely considered important in the knowledge management environment (e.g., cross-functional virtual teams, collaborative work, distributed tacit and explicit knowledge, both routine and nonroutine work processes, a dynamic market/organizational environment) and illustrates the use and utility of our integrated approach to analysis and design of knowledge systems and processes. The final section closes with key conclusions and implications for practice, in addition to a focused agenda for future research along these lines.

Knowledge Management Background

In this section, we summarize background information from the knowledge management literature. Drawing from Nissen et al. (2000) to help organize this discussion, we employ a two-dimensional feature space of specific activities and stages comprising knowledge management as a process. We begin discussion of the first dimension by drawing from the literature to integrate a number of various life cycle models emerging for managing knowledge.

Nissen et al. (2000) observe a sense of process flow or a life cycle associated with knowledge management, and integrating their survey of the literature (e.g., Davenport & Prusak, 1998; Despres & Chauvel, 1999; Gartner Group, 1998; Nissen, 1999), they synthesize an amalgamated knowledge management life cycle model as outlined in Table 1. Briefly, the "create" phase begins the life cycle, as new knowledge is generated by an enterprise. The second phase pertains to the organization, mapping or bundling of knowledge. Phase three addresses some mechanism for making knowledge formal or explicit, and the fourth phase concerns the ability to share or distribute knowledge in the enterprise. Knowledge application for problem solving or decision making in the organization constitutes phase five, and a sixth phase is included to cover knowledge evolution, which reflects organizational learning through time.

The second dimension is termed knowledge management level and draws from Nonaka (1994) and others (e.g., Despres & Chauvel, 1999). The knowledge management level includes both individual and collective entities, the latter of which are further distinguished between groups (e.g., relatively small collections such as work teams or functional departments) and organizations (e.g., relatively large collections such as enterprises or corporations). This dimension pertains to the

Table 1: Knowledge management life cycle models (Adapted from Nissen et al., 2000)

Model	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5	Phase 6
Nissen	Capture	Organize	Formalize	Distribute	Apply	
Despres & Chauvel	Create	Map/bundle	Store	Share/transfer	Reuse	Evolve
Gartner Group	Create	Organize	Capture	Access	Use	
Davenport & Prusak	Generate		Codify	Transfer		
Amalgamated	Create	Organize	Formalize	Distribute	Apply	Evolve

reach of knowledge management through the enterprise. Combined with the life cycle steps from above, we employ these levels to classify extant knowledge management applications.

Drawing further from the prior research discussed above, we note the coverage of extant systems and practices across these two dimensions–knowledge management life cycle phase and knowledge management level–is patchy. For instance, across all three knowledge management levels, numerous systems and practices are identified from the literature to support three of the six life cycle phases: knowledge organization, knowledge formalization and knowledge distribution. But relatively few counterpart systems and practices are found to correspond with the other three phases: knowledge application, knowledge evolution and knowledge creation. We thus observe a relative abundance and dearth of systems and practices available to support these respective phases of the KM life cycle (see Nissen et al., 2000, for details).

Integrated Framework

The feature space of systems and technologies outlined above defines a broad design space for KM systems. The design space is further defined and constrained in this section by a set of contextual factors that impinge on the implementation of these systems in organizations. In the prior research, three complementary design methods are identified and integrated to address knowledge management. These methods draw from business process reengineering (BPR), expert systems (ES) development, and information systems (IS) analysis and design. Each plays a key role in the progression of knowledge process design, through knowledge analysis, and onto information system design. And a key contribution of this prior work involves integration of these methods into a single, coherent knowledge management design methodology.

To summarize, the prior researchers combine the two-dimensional feature space from above with contextual analysis to outline an integrated framework for knowledge process and system design. In short, one first analyzes the processes associated with knowledge work performed in the enterprise. This step draws from common reengineering methods (e.g., Davenport, 1993; Hammer & Champy, 1993; Harrington, 1991). Each process of interest must be understood and analyzed–and perhaps redesigned–to interpret the knowledge required for its effective performance. For instance, a recently developed, measurement-driven redesign method (cf. Nissen, 1998) can be particularly useful for identifying and treating process pathologies in advance of system design.

The next step is to identify and analyze the underlying knowledge itself. The two-dimensional framework for analysis–combining phases of the amalgamated knowledge management life cycle with knowledge levels–facilitates this analysis. And we draw from textbook knowledge engineering methods employed for development of expert systems (cf. Russell & Norvig, 1995; Turban & Aronson, 2001). Because such methods focus directly on knowledge–as opposed to data and information–analysis at this stage can obviate many problems associated with knowledge management systems in development today. And as a useful side effect, mechanisms such as rules, frames, semantic nets and similar knowledge engineering techniques can be used to represent enterprise knowledge, tacit as well as explicit. Once represented in digital form, these techniques can support direct application and evolution of knowledge. Recall from the discussion above that such enhanced knowledge management activities are poorly supported by systems and practices in use today.

In the third stage of analysis, one must assess the contextual factors associated with the process of interest. Critical in this assessment is understanding the organization and the nature of knowledge underlying the task. Specifically, Nissen et al. (2000) indicate that organizational memory represents an important design consideration, as do organizational structure and the incentives used to stimulate workers to contribute knowledge to systems. Also key is the nature of knowledge underlying process tasks. In particular, the distribution of canonical and non-canonical knowledge and practices through the enterprise exerts strong constraints over the types of systems that can be employed for knowledge management.

Finally, armed with results from these three levels of analysis (i.e., process, knowledge, and context), one can then effectively analyze and design the information systems required to automate and support knowledge work in the process. To accomplish this final stage of analysis, traditional IS methods (e.g., use of data flow diagrams, entity-relationship diagrams, object models and use cases) are employed. We find it interesting to note, most current knowledge management projects start at this (final) stage of analysis.

NAVAL BATTLE GROUP APPLICATION

This section applies the knowledge management framework from above to the U.S. Navy battle group theater transition process (BGTTP). The BGTTP represents an extreme process in terms of knowledge-transfer demands, so it serves as a useful process for investigation and subsequent generalization of results. We begin with background information pertaining to the BGTTP and describe our application to key knowledge tasks that greatly impact the outcome of the deployment process. We then address how a process and system can be designed to improve knowledge transfer, both across time and between different organizations. This process is described in considerable detail by Oxendine (2000).

BGTTP Background

As the United States Navy continues to support the naval strategic concept "Forward … From the Sea" (Boorda, Dalton & Mundy, 1992) into the 21st century, one of the Navy's primary responsibilities is to maintain a forward presence throughout the world and project power to possibly deter actions that may threaten U.S. interests. In order to support this objective, the Department of the Navy (DoN) maintains naval forces abroad and periodically deploys ships throughout the high seas to protect U.S. interests. With this, the Navy has long used the carrier battle group (CVBG) as an instrument for power projection and forward presence.

The CVBG is a combat formation of ships and aircraft, which comprises a principal element of U.S. national power projection capability. It is the essential foundation of U.S. ability to conduct operations envisioned in "Forward … From the Sea." The CVBG includes capabilities sufficient to accomplish a variety of combat tasks in war, and it serves a wide variety of functions in situations short of war. The CVBG's peacetime mission is to conduct forward presence operations to help shape the strategic environment by deterring conflict, building interoperability, and responding, as necessary, to fast-breaking crises with the demonstration and application of credible combat power (OPNAV, 1995).

In order to support this peacetime objective, the DoN periodically deploys CVBGs to theaters of U.S. interests (e.g., the Arabian Gulf). Typically, a CVBG remains on station for 3 months. Subsequently, the CVBG personnel, equipment, and support are relieved by another CVBG, which conducts a successive 3-month deployment in theater. This periodic BG rotation continues four times a year or until the theater is no longer deemed in need of battle group presence. In the case of battle groups in the Arabian Gulf, for reference, such BG rotations have been recurring since the Gulf War over a decade ago.

The transition from one CVBG to another in theater is facilitated by the BGTTP. The primary objective of this process is to capture and transfer knowledge between CVBGs in order to reduce the arriving battle group's (BG) theater acclimation period. The acclimation period is the time it takes for the arriving BG to become familiar with the new environment (e.g., understanding the nature and seriousness of regional threats). During each acclimation period, the arriving BG is at some risk in terms of effectively responding to any indication and warning (I&W) and engaging a potential threat accordingly if the immediate need arises. The current theater turnover process provides the arriving BG with explicit theater background information, but the regional experience and local knowledge gained through theater operations by the departing BG is not transferred well during the process. Although IT has helped facilitate the BGTTP, only data and information are transferred at present, not knowledge.

If the arriving BG is to effectively conduct its peacetime and wartime missions, it must possess as much knowledge of the theater in which it is operating as the departing BG, the latter of which has been on station for 3 months. By applying our integrated knowledge process and system design method to the BGTTP, we seek to significantly improve the flow of knowledge from one BG to another. As an objective, one might then expect the arriving BG to perform on Day 1 of operations in theater as effectively as the departing BG on its 90th day.

Because the BGTTP as a whole represents a large, complex process (e.g., involving roughly 15 ships, 15,000 people at sea, often off the coast of a hostile nation), we focus this investigation on a relatively small, but absolutely critical, subprocess associated with the transfer of knowledge acquired by naval intelligence officers. And through field research (Oxendine, 2000), we find a central component of such intelligence officers' knowledge pertains to the identification of patterns and norms and trend analysis.

Specifically, learning to recognize patterns and norms represents the key knowledge desired by CVBG commanders prior to entering the Arabian Gulf, and the ability to perform trend analysis represents the key knowledge acquired on station. Together, the identification and continued analysis of patterns and norms are essential for planning and conducting safe and effective operations in the Arabian Gulf. Tactically speaking, these activities are referred to as intelligence preparation of the battlespace (IPB) and used primarily for I&W. As per Naval Doctrine Publication 2 (1994), IPB is the systematic and continuous analysis of the current or potential adversary, terrain and weather in the battlespace.

Process Analysis

Drawing from the integrated framework above, the first step involves process analysis. We perform this high-level analytical step in two increments. The first involves the kind of process-redesign analysis that is customary in reengineering engagements (cf. Davenport, 1993; Hammer & Champy, 1993). Such redesign analysis focuses on work-process flows that we term horizontal processes, for their representations are generally presented as directed graphs, with process activities running horizontally across the page. This first increment of analysis provides guidance for (re)designing the process, for example, to overcome process pathologies. The second increment involves knowledge management aspects of the process. Such knowledge management analysis focuses on cross-process flows that we term vertical processes (cf. Nissen & Espino, 2000). These latter process representations are also generally presented as directed graphs. But the corresponding process activities run vertically down the page, across the kinds of work-process flows (i.e., horizontal processes) examined for redesign. We return to the concept of vertical processes in a subsequent section below.

Redesign Analysis. The battle group intelligence process is delineated in Figure 1. In this representation, process activities are denoted by nodes in a graph, which are connected by edges to denote the flow of work through the process. Each activity node also includes eight attributes to describe the corresponding work tasks: 1) activity name, 2) role of the agent responsible for its performance, 3) organization associated with the activity, 4) inputs to the activity, 5) outputs from the activity, 6) IT employed to support the activity, 7) IT employed to support communication, and 8) IT employed to automate the activity.

For example, in the first step of data collection, shipboard systems (e.g., networks, radios, radar and other sensors) receive and provide raw intelligence data to users. In this case, the user is an intelligence watchstander on a tactical I&W watch, which involves vigilantly scanning and monitoring the environment in search of potential threats. This watchstander is either part of the BG intelligence staff (N2) or the carrier intelligence center (CVIC). After the data are collected, the N2 staff or the CVIC intelligence analysis and reporting cell (A&R) uses various IT applications to process the raw data and convert them into a usable form of information. Subsequently, intelligence personnel conduct trend analysis by integrating, analyzing, evaluating, and interpreting the processed information. The N2 staff or the A&R uses various IT tools to incorporate the data and produce an intelligence product that is distributed to the BG and destroyer squadron (DESRON) commanders. Commanders, in turn, integrate the intelligence product with their own experience and observations to produce actionable knowledge.

The representation in Figure 1 supports the kind of process analysis generally associated with business process reengineering. And as noted above, using this representation, one would strive to understand and possibly redesign the process at this stage. We obtain diagnostic measurements from the process and employ the KOPeR system (cf. Russell & Norvig, 1995) to support its redesign. KOPeR is an expert system that automates and supports key aspects of process redesign.

The key measurements are summarized in Table 2. From measured values presented in the table, one can see the baseline process suffers from a number of serious pathologies (e.g., sequential flows, process friction, and manual, paper-based & labor-intensive processes). We return to use this diagnostic information to drive process redesign in a subsequent section below.

Knowledge Management Analysis. To support integrated knowledge process and system design, we extend the process diagram from Figure 1 to reflect its performance through time and across different BGs. This extended process

Figure 1: Battle group intelligence process

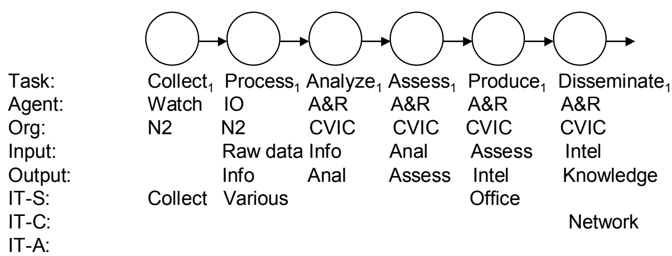


Table 2: Process measurements and diagnoses

Configuration Measure	**Value**	**Diagnosis**
Parallelism	1.00*	Sequential process flows
Handoffs fraction	0.33	Friction
Feedback fraction	0.16	OK
IT support fraction	0.50	Manual process
IT communication fraction	0.16	Paper-based process
IT automation fraction	0.00*	Labor-intensive process

* denotes theoretical extremum for a measure

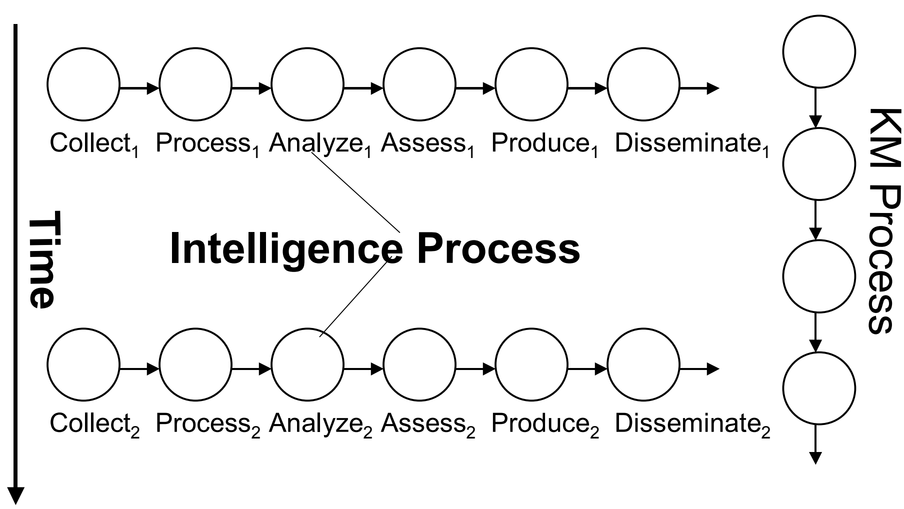
representation augments the horizontal process graph presented in Figure 1 to also include vertical processes that flow across various work-process flows. This cross-process perspective facilitates process design in terms of knowledge management and is depicted in Figure 2.

Here, we show the same basic process flow (e.g., activities represented by nodes and connected by directed edges) for two particular instantiations of the process. In the first instantiation (activities with the subscript 1, e.g., "Collect_1"), a particular BG would perform each of the process activities (i.e., as represented by nodes in the figure) at some point in time. At some other point in time, another instantiation of the process (activities with the subscript 2, e.g., "Collect_2") would proceed through the same process activities. However, this latter instantiation involves a different BG team and is enacted at a later point in time (e.g., following a 90-day deployment). A principal concern in terms of knowledge management involves consistency and efficacy across process instantiations. This vertical process provides the basis for knowledge flow in the enterprise.

For instance, prior research focused on the U.S. Coast Guard (Nissen & Espino, 2000) identified seven cross-process flows associated with the maritime-interdiction process: 1) personnel assignment, 2) after-action review (AAR), 3) qualification, 4) debrief, 5) training, 6) post-deployment debrief, and 7) IT support. These and other vertical-process examples may also apply well to our BGTTP. But for space considerations, we do not detail these processes here. Clearly, the cross-process flows represent the essence of knowledge management activities.

Knowledge Analysis. The second step involves knowledge analysis. For integrated knowledge process and system design, we need to focus on vertical processes as well as their horizontal, work-process counterparts. Prior to conducting knowledge analysis, the organization's mission and goals must be understood. Subsequently, knowledge analysis involves identifying key knowledge within an

Figure 2: BG vertical processes



organization and results in a thorough understanding of critical success factors (CSFs). The term knowledge mapping could be substituted, with caution, for knowledge analysis here. Knowledge analysis also identifies the key explicit and tacit knowledge employed to make decisions and take action (Nissen et al., 2000).

CVBGs are capable of conducting a variety of missions depending on the theater of operations and its geopolitical environment. For CVBGs operating in the Arabian Gulf, the key BG operations are Operation Southern Watch (OSW), led by the BG commander, and maritime-interdiction operations (MIO), led by the DESRON commander. Each operation has a primary objective and CSFs as listed in Table 3. The success of each operation depends on the achievement of each CSF, thus accomplishing the primary objective.

For both BG operations, intelligence is a significant factor and provides key knowledge essential for success. Both operations require a high degree of situational awareness derived from trend analysis. The intelligence officer provides this intelligence support to the BG commander and his staff for day-to-day decision making regarding OSW and MIO. To develop and acquire the analytical skill applied in trend analysis requires training, experience and specific knowledge, both explicit and tacit.

Explicit knowledge of patterns and norms is accessible prior to deployment

Table 3: Mission objectives and critical success factors

Operation Southern Watch (OSW) *Primary Objective* ➢ Enforce the No-Fly Zone in southern Iraq *Critical Success Factors* ➢ High situational awareness (current, accurate intelligence) ➢ Prevent violation ➢ Complete air tasking order (ATO) ➢ Good, reliable communication within theater ➢ Adequate I&W of potential violation
Maritime-Interdiction Operations (MIO) *Primary Objective* ➢ Enforce economic sanctions against Iraq *Critical Success Factors* ➢ High situational awareness (current, accurate intelligence) ➢ Good, reliable communication within theater ➢ Well-trained and properly equipped boarding crew ➢ Sufficient assets for ship placement and boardings ➢ Prevent violation

through various intelligence products, such as manuals, books, lessons learned and training exercises. And the BG intelligence staff systematically relies on an 18-month inter-deployment training cycle (IDTC) to prepare for deployment. The IDTC's primary purpose is to increase the unit's readiness, teamwork and warfighting skills. During the IDTC, the BG intelligence staff conducts exercises simulating operations in the threat environment. These training exercises serve as an introduction to provide the intelligence staff with explicit theater knowledge of the threat and operating environment. Prior to deployment, the N2 provides the BG and DESRON commanders with known patterns and norms, which are used for deliberate planning. As per NDP 2, in deliberate planning the commander's emphasis is on developing a carefully crafted plan for military operations.

Unlike such explicit knowledge, however, tacit knowledge used in trend analysis is not readily accessible, and it is gained only through on-the-job training (OJT) and experience. In other words, formal training during the IDTC provides only explicit, not tacit, knowledge. Tacit knowledge is necessary to classify operations or activities as "normal" or "abnormal," for instance, and such identification is based on how each individual analyst evaluates and interprets the data. For contrast with deliberate planning from above, classification of an activity or operation as "abnormal" is used as I&W, which supports crisis-action planning.

In crisis-action planning, the commander's emphasis is on quickly developing a course of action to respond to an emergent crisis. Currently, the intelligence staff acquires tacit knowledge required for support of such crisis-action planning only through physical presence and operations in the Gulf. Thus, such tacit knowledge represents the focus of our efforts to improve knowledge flow.

Contextual Analysis. The third step involves contextual analysis. As with most organizations, explicit knowledge is readily available when required by BGs (e.g., in the form of manuals, policies, intelligence reports). Table 4 outlines current methods used to codify and transfer knowledge. But BGs do not codify tacit knowledge required to perform their responsibilities because there is no organized system in place to assist in transferring such knowledge. Rather, the majority of tacit knowledge is obtained, at the individual level, through OJT. Even when turnovers are conducted via face-to-face meetings between arriving and departing BG representatives (e.g., exchanging documents, providing briefings, answering questions), reading and hearing stories about I&W or crisis-planning activities are not the same as identifying and experiencing them firsthand.

IS Analysis and Design. The fourth step involves IS analysis and design. To reiterate from above, IT represents a powerful enabler of knowledge management. But we find that process (re)design, along with knowledge and contextual analysis, is necessary before implementing IT. For instance, the pathologies diagnosed above (e.g., manual, paper-based, and labor-intensive processes) provide guidance for IT applications at this stage of analysis, and contextual factors serve to highlight constraints that require consideration at this stage.

Table 4: Current BGTTP methods

BGTTP Instruments
Lessons Learned - Review on-station CVBG's mid-cruise and end-of-cruise lessons learned via Web site, e-mail, or message traffic - Review 6 mos or less prior to deployment
Secret Internet Protocol Routing Network (SIPRNET) - Access command Web sites - E-mail relieving fleet counterpart and others throughout course of deployment
Inter-Deployment Training Cycle (IDTC) - Initiate 18 mos prior to deployment - Increase unit's readiness, teamwork and warfighting skills prior to deployment
Message Traffic - Add relieving CVBG to message traffic list to receive routine message traffic - Receive departing CVBG's message traffic 6 mos prior to deployment
Phone - Use secure phone (STU III) when enroute to Gulf

In system analysis, the organization's current procedures and information systems used to perform organizational tasks are analyzed. For trend analysis, there is no formal IT system presently capable of capturing and sharing the departing CVBG's tacit knowledge and experience. As indicated in the KOPeR diagnosis, the current process lacks adequate IT in the support and communication areas.

In order to treat these pathologies, three requirements emerge for systems to improve knowledge flow: 1) serves as a knowledge repository; 2) facilitates knowledge exchange; and 3) captures and transfers tacit knowledge. We use these three requirements to guide development of corresponding BG intelligence process redesigns.

BG Intelligence Process Redesigns

Recalling the KOPeR diagnosis of the intelligence process from above, the "as is" trend analysis process requires improvement in IT support and communication. In this current process, IT is not used to capture and exchange knowledge necessary for effective trend analysis. As a result, the intelligence staffs of CVBGs repeatedly construct new knowledge bases that are common to, but not shared with, those of other CVBG intelligence staffs. Therefore, we focus on IT to correct the current trend analysis process pathologies.

Specifically, we concentrate on knowledge repositories, groupware and knowledge-based systems (KBS). Knowledge repositories (e.g., via Web) are relatively quick and easy to construct, but they require some degree of user expertise and time to find specific desired knowledge because the user must search manually. Conversely, KBS (e.g., expert systems, intelligent agents) require minimum user expertise and time to find the desired knowledge, but formal capture and organization of knowledge, which is required to construct the knowledge base, can be difficult and time consuming. Groupware falls somewhere in between the two. Knowledge repositories, groupware and KBS are employed in turn to redesign the BGTTP below.

Redesign 1: Knowledge Repositories. Through repositories, corporate knowledge can be organized and saved for future use. Knowledge repositories capture and maintain structured, explicit knowledge, usually in document form, for use throughout an organization. There are three basic types of repositories: 1) external knowledge (e.g., competitive intelligence), which refers to knowledge about external entities, 2) structured internal knowledge (e.g., research reports, techniques and methods), and 3) informal internal knowledge (e.g., discussion databases full of know-how, sometimes referred to as "lessons learned"; see Davenport et al., 1998).

The knowledge applied in trend analysis is tacit: plain and simple know-how. To transfer tacit knowledge from individuals into a repository, some sort of community-based electronic discussion is often employed. This type of knowledge repository, a combination of structured internal and informal internal knowledge, is an attempt to accelerate and broaden the traditional knowledge sharing that happens with the socialization of newcomers, the generation of myths and stories within communities of practice, and the general transmission of cultural rituals and organizational routines (Davenport et al., 1998).

While such knowledge is relatively quick and easy to capture and store, unless some means for effectively indexing and searching it is established, knowledge stored in repositories can be very difficult to find, particularly under time constraints (e.g., when in crisis mode). Unfortunately, such indexing and searching techniques remain somewhat primitive at present and are the focus of current research. Thus, repositories are principally limited to explicit knowledge at present and therefore likely to be used mostly for deliberate planning.

Redesign 2: Groupware. Today, groupware is becoming more prevalent in enterprises as a tool to help teams operate more effectively across geographical distances and innovate by building on shared corporate knowledge. Groupware is software that permits two or more people to communicate and collaborate across geographical and temporal boundaries, and it is the cornerstone for most electronic knowledge sharing (Liebowitz, 1999). Groupware provides rich content and real interactivity via presentations, demonstrations, e-whiteboards, chat, audio, and video. Through groupware, people separated by space (and time) can interact using many of the same rich communication media customarily employed for face-to-face conversations. Although it is technically feasible to capture and store such groupware interactions (e.g., in repositories of audio-video conversations), problems noted above associated with organization and search remain and impede effective, timely retrieval. This repository-focused application of groupware is, therefore, also relegated principally to support of deliberate planning.

Alternatively, by using groupware interactions as surrogates for face-to-face conversations, at least some tacit knowledge can be transferred in a way inconceivable through formal reports (e.g., lessons learned), repositories (e.g., Web content) or other textual approaches. Specifically, through real-time groupware interaction, personnel assigned to an arriving BG can participate in intelligence operations of the BG on station through a moderate form of telepresence. Such, active participation (even though remote) may lead to development of comparable levels of tacit knowledge that are normally acquired by intelligence personnel on station through OJT. This represents a substantial improvement over the repository approach from above. But, of course, such tacit knowledge is ephemeral and likely to require relearning on the successive BG transfer.

Redesign 3: Expert Systems. Expert systems (ES) are programs that assist nonexperts in making decisions comparable to those of experts. An expert system emulates the interaction between user and expert in a specific domain (e.g., medicine, electronics, finance). Unlike other KM technologies, which assume the user already possesses knowledge about the subject, ES allow almost anyone to solve problems and make decisions in a subject area. ES capture part of an expert's decision-making knowledge, store it in a knowledge base, and allow its effective dissemination to users through an interface (Frenzel, 1987; Liebowitz, 1999; Russell & Norvig, 1995).

Given that an expert system has a knowledge base and an inferencing capability, it can be used to assist the intelligence staff in conducting trend analysis. First, knowledge and expertise used to conduct trend analysis must be codified and stored in the expert system's knowledge base. Clearly, such capture and formalization is nontrivial, as this step has long been acknowledged as the bottleneck in ES development (Jackson, 1990) across nearly every application domain. However, an effective set of knowledge-engineering tools and techniques has been developed and refined over the last 40 years, and ES applications have been successfully implemented in many critical areas, including medicine (e.g., MYCIN; see Shortliffe, 1976), computer design (e.g., R1/XCON; see McDermott, 1982), electronics troubleshooting (e.g., SOPHIE; see Brown, Burton & de Kleer, 1982) and others. Although expected to be difficult and time-consuming, acquiring key knowledge required for effective trend analysis appears to represent an achievable knowledge-engineering task as well.

Once operational, the expert system would interact with and assist the user in conducting trend analysis. For instance, certain flight profiles (e.g., course, speed, altitude, maneuvers) of non-allied aircraft in the region occur routinely and now appear to be associated with pilot training. But until a trend associated with such flights can be established, the profiles themselves possibly appear to represent hostile profiles, and intelligence analysts lacking specific, tacit knowledge associated with pilot training profiles can lead to overreaction by BG commanders and crews. Alternatively, an ES could be developed to recognize and correctly interpret such profiles, just as experienced intelligence analysts do after serving on station for some time in the region.

Further, once such an expert system has been developed to assist the intelligence staff in conducting trend analysis, the associated knowledge has been made explicit, and the expert system itself, as an application of information technology, can be duplicated and transferred from one BG to another. This represents a quantum shift in capability regarding knowledge flow in the CVBG enterprise. Whereas the ships and personnel comprising one BG or another are separate and distinct (i.e., negligible overlap or interchange of ships or personnel), knowledge captured and formalized via ES can remain on station in a given theater of operations indefinitely. It therefore serves not only as a repository of intelligence knowledge that can easily be passed between outgoing and incoming CVBGs, but it can also improve the performance of all subsequent BGs, as this knowledge may be refined and improved through time. Such use of ES, thus, represents a fundamental change to our vertical process, which, we reemphasize is central to KM and knowledge flow.

Migration plan. With these three redesigns, we need to establish a migration plan for transitioning the intelligence process from its current, baseline or "as is" configuration. This plan envisions near, medium and far-term migrations that incorporate the three redesign alternatives developed above. For the near term (i.e., immediately), the Navy should continue building repositories for explicit knowledge and making them available to geographically dispersed units via networks. Compared to paper-based documents and learning such explicit knowledge by trial and error, network availability represents a qualitative improvement. Rather than calling this a "redesign" per se, Redesign 1 represents more of a confirmation that current BG practices and plans appear to be on target in terms of promoting knowledge flow. Nonetheless, problems noted above with respect to repositories (e.g., indexing, search) serve to mitigate the efficacy of this approach in terms of tacit knowledge flow.

Over the medium term (e.g., next 1-2 years), results of this analysis suggest the Navy should employ groupware technology and apply it as an instrument to facilitate the exchange of tacit knowledge. As noted above, groupware supports tacit knowledge exchange with rich communication media that serve as surrogates for face-to-face conversations, and they enable remote participation in intelligence processes via moderate telepresence. Interestingly, acknowledging this redesign, groupware technology is already being implemented within the STENNIS CVBG, and plans are underway to implement the same groupware technology within other battle groups as well.

However, problems noted above with respect to groupware (e.g., ephemeral knowledge) also serve to mitigate the efficacy of this approach in terms of knowledge flow. Moreover, if the individual commands do not support this effort, then relying on personnel to share knowledge or contribute to the knowledge base is impractical (Davenport & Prusak, 1998; Frenzel, 1987; Russell & Norvig, 1995).

In the far term (e.g., 3-5 years), expert systems should be developed to assist with and partially automate key aspects of the intelligence process. Once difficulties with knowledge engineering are overcome, this approach offers great potential to decrease the acclimation period required by arriving CVBGs. And if the associated knowledge bases can be updated and refined over time, it is conceivable that the BGTTP may some day be seamless and transparent; that is, the arriving BG may someday be just as capable on Day 1 of operations in theater as its departing counterpart on Day 90. This would represent a substantial feat in terms of knowledge flow.

CONCLUSIONS AND FUTURE RESEARCH

The research described in this paper focuses on knowledge process and system design from three integrated perspectives: 1) reengineering process innovation, 2) expert systems knowledge acquisition and representation, and 3) information systems analysis and design. Building upon prior work, we show how to integrate these three perspectives in a systematic manner, beginning with analysis and design of the enterprise process of interest, progressively moving into knowledge capture and formalization, and then system design and implementation. With this, we illustrate the use and utility of integrated knowledge process and system design through an application to the battle group theater transition process (BGTTP), which represents an extreme example in terms of knowledge-transfer requirements. This provides a central contribution of the paper, as it reveals the underlying components of KM, prescribes design guidance specific to each and demonstrates how the integrated framework for knowledge process and system design can be effectively applied to a nontrivial, real-world, knowledge-intensive process.

A number of other important findings and conclusions emerge from this research. First, an organization must clearly define its goals and CSFs in order to design a suitable KM system. Otherwise, it will be difficult to identify the appropriate cross-process flows that nurture knowledge transfer. Second, the paper reemphasizes the fact that analysis of the process, knowledge and context is important in designing an appropriate KM system. Focusing on technology alone will, more often than not, result in a system that does not serve the organization.

Third, the techniques and technologies identified to redesign intelligence processes appear to also offer potential for improving other CVBG activities (e.g., operations), and results of this investigation should help focus and streamline IS development targeted for the battle group. Finally, we note that the forward-presence environment associated with CVBGs represents a unique context in terms of process performance. But we see no reason why the integrated framework for process and system design (i.e., as presented and discussed in the paper) cannot be effectively employed for a variety of other processes, within the Navy and beyond. Thus, we feel the results of this investigation are highly generalizable. Indeed, the power of such a framework may derive from its robustness and broad applicability. And we see a fruitful line of continued research along these lines.

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Chapter XIX

A Case Study of Project Champion Departure in Expert Systems Development

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Research on project champions has focused on the characteristics of this individual and how to provide encouragement and support. An understanding of the role of project champion is shortsighted, however, without a realization of what can happen to an expert system (ES) project and what can be done, should this individual depart. This paper discusses the ES project champion by examining the experiences of Ciba-Geigy Corporation with an ES project impeded by the departure of the project champion. The OpBright expert system, developed to support the identification of appropriate optical brightener products by sales representatives, was intended to provide a competitive advantage through superior customer service. With the promotion and transfer of the vital force committed to the project's success, the ES encountered a stalemate. The difficulties in maintaining momentum for the ES without a project champion are discussed. Finally, suggestions are presented to guide organizations away from the same fate.

INTRODUCTION

Since the time of Schon's (1963) seminal work, the role of project champion has been recognized as a vital force in successful project development and implementation. A project champion for information systems (IS) projects has been defined as "a key individual, whose personal efforts in support of the system are critical to its successful adoption" (Curley & Gremillion, 1983, p. 206). The role of project champion for expert system (ES) projects in particular has been recognized as critical to the successful application of this technology (Hayes-Roth & Jacobstein, 1994; Sipior & Volonino, 1991; Wong, 1996).

What makes champions of ES projects different from those of other projects is the additional need to identify and manage internal areas of knowledge and expertise to the benefit of the organization. It is widely recognized that effective knowledge management expertise can impact business performance (Alavi & Leidner 1999; Hansen, Nohria & Tierney, 1999; Zack, 1999). The expertise employees have acquired over the years is a valued resource. The development of organizational processes to effectively capture and share employee knowledge and expertise is important in managing this resource. In response, ES provide the capability for documentation and distribution of knowledge and expertise, facilitating knowledge-sharing.

Perhaps the role of project champion for ES nonetheless does not differ from that of other projects. However, ES have still not achieved widespread application. There still is a lack of awareness of the capabilities offered by ES in documenting and distributing expertise, how ES are developed and maintained, and how ES can beneficially be integrated into corporate operations. Successful ES implementation requires not only an appropriate domain, functional completeness and correctness, and tight integration with existing systems and business processes (Hayes-Roth & Jacobstein, 1994; Mattei, 2001), but "a significant amount of organizational and managerial effort to cause its adoption" (Sviokla, 1996). ES technology has advanced to the point where unsuccessful implementation is often the result of mismanagement of technology, rather than failings of the technology itself. Thus, an understanding of the role of an ES project champion can provide insight to organizations seeking to apply this technology. Although the current literature does not directly address the loss of the driving force behind an ES project, an understanding of the role of the project champion is shortsighted without a realization of what can happen to a project and what can be done, should this individual depart.

This paper first addresses the need to manage corporate expertise. To exemplify the characteristics and importance of the ES project champion, the experiences of Ciba-Geigy Corporation with an ES project are examined. The OpBright expert system, developed to support the identification of appropriate optical brightener products, was intended to provide a competitive advantage through superior customer service, a recognized benefit of expert system applications (Mattei, 2001). With the promotion and transfer of the vital force committed to the project's success, the ES encountered a stalemate. The difficulties in maintaining momentum for the ES without a project champion are discussed. Finally, suggestions are presented to guide organizations away from the same fate.

THE NEED FOR KNOWLEDGE MANAGEMENT

The necessity to manage knowledge and expertise is particularly acute for knowledge-intensive industries such as chemicals, electronics, financial services, information technology (IT), and pharmaceuticals. Tellers and customer service representatives are confronted with a wide range of highly visible decisions involving customers, requiring judgment calls on a daily basis. Knowing how to expertly handle various situations can take years of experience. Often, inexperienced employees make decisions without full or appropriate knowledge.

Astute management can preclude the loss of valuable corporate knowledge and expertise due to normal turnover or absence (Mattei, 2001), promotion (Prietula & Simon, 1989), or retirement. ES offer the capability to capture, document, and distribute valuable organizational expertise, offering many opportunities and benefits (Mattei, 2001). Included among these are greater consistency in applying knowledge, increased accessibility to expertise, curtailed loss of expertise, improved training, and increased job satisfaction. Can the role of project champion enable effective identification of appropriate areas of expertise for ES development to achieve such benefits?

THE ROLE OF PROJECT CHAMPION

Drawing upon the current literature on champions, the characteristics and behaviors exhibited by these individuals are discussed. An understanding of project champions can enable organizations to recognize the mechanisms necessary to support the champion and subsequently maintain momentum for an ES project, should the champion depart.

Formal Position Within an Organization

A project champion is frequently an executive from the business area of application (Earl, Feeny, Lockett & Runge, 1988), but not necessarily (Sumner, 2000). A champion may even come from another organization, such as a consulting firm or vendor (Thomas, 1999). Beath (1991) defines this individual as a manager; however, individuals from various formal positions have assumed the role (Earl et al., 1988; Mayhew, 1999; Pinto & Slevin, 1989; Thomas, 1999). The champion may be from any part of an organization, but surprisingly may rarely come from formal IT functions (Martinsons, 1993). Champions have been reported to view managers of IT as too conservative, adversaries to technological innovations, and even inept (Beath & Ives, 1988).

Rather than being assigned to the role, it is an individual’s interest and personal conviction to a project which lead him to emerge as project champion (Pinto & Slevin, 1989; Schon, 1963). Based on a review of empirical evidence, Howell and Higgins (1990) conclude that formally appointing an individual to this role could actually lead to its demise. Greater pressure to perform may diminish the intrinsic motivation felt by the individual, as he must personally be convinced of the value of a project. Once convinced, the project champion exhibits an entrepreneurial spirit (Bolton & Thompson, 2000; Pinto & Slevin, 1989; Schon, 1963), dedicating time and energy to personally rally others to see the project through to completion.

Leadership Qualities

By contributing belief in and commitment to a project, the champion tends to go well beyond job responsibilities and may even go against management directives (Beath, 1991; Curley and Gremillion, 1983; Earl et al., 1988) to achieve project success. Project champions have been characterized as more than ordinary leaders; rather, they exhibit transformational leadership behaviors which inspire others to transcend their own self-interests for a higher collective purpose (Howell & Higgins, 1990).

Transformational leaders have empirically been found to exhibit any of four characteristics, including charisma, inspiration, intellectual stimulation, and individualized consideration to drive others into action (Beath, 1991; Howell & Higgins, 1990; Landers, 1999). Charismatic behavior captivates others into believing in the project as the champion himself does. Others are drawn to the champion by their respect and loyalty for him and strive to higher levels of performance. Through inspirational behavior, the champion influences others by using emotional appeals to elevate their performance. Vivid and persuasive images of the project's potential increase the motivation of the followers (Mayhew, 1999). Intellectual stimulation challenges others to aspire to imaginative use of their individual skills. In confronting circumstances impeding project progress, followers apply themselves in response to the champion's encouragement to think on their own and develop creative means of problem resolution.

Champions are excellent time managers. They devise schedules, run efficient meetings according to an agenda, itemize an action list, and follow up with others to complete action items (Landers, 1999). The leadership behaviors of champions are particularly valuable for implementing systems intended to bring about organizational change (Beath, 1991; Earl et al., 1988; Landers, 1999). Implementation often entails process redesign with far-reaching organizational change, such as redefining responsibilities, realigning lines of authority, shifting power centers, and adjusting reward schemes (Rockart, 1988). As knowledge repositories, ES certainly have the potential to invoke change of this nature. Transformational leadership qualities enable the champion to maintain project momentum as difficulties associated with resource allocation and political derailment are encountered. Because of their skills in bringing about change, champions have been recognized to be change agents (Beath, 1991; Curley & Gremillion, 1983; Landers, 1999).

Base of Power Within Organizations

To oversee a project, some level of power is held by project champions (Earl et al., 1988; Mayhew, 1999; Pinto & Slevin, 1989), whether it be attributed to formal position or personal relationships. The responsibilities of a formal position may inherently grant power to a champion. If not granted power by virtue of position, the champion gains power through personal relationships. Champions have been found to be perceived as influential or prestigious by organizational members (Curley & Gremillion, 1983; Maidique, 1980). The opinion held by others may be the result of a carefully planned influence strategy. The champion may bolster his own image by descriptively portraying his endeavors as brilliant feats, resulting in positive impacts throughout the organization. One or more influence strategies are employed to attract followers (Schon, 1963), such as impression building, rational justification, assertion, and persuasive communication (Howell & Higgins, 1990).

Champions utilizing impression building portray outcomes of their endeavors as highly positive achievements to promote an image of competence and success. A rational presentation of how the project advances goals and objectives and upholds values of the organization offers analytical justification, which is logically sound. Assertion of the project's potential benefits is a more authoritative approach to convince others to dedicate their efforts to the project. Persuasion relies more on persistence, rather than clear and concise arguments, to attain agreement. These strategies are intended to foster the confidence of others, secure the necessary resources, actively promote the project, and overcome resistance to approval (Howell & Higgins, 1990). For example, Burgelman (1983) found that champions were persistent in expressing beliefs in a new corporate venture to the extent that top managers became convinced of its strategic importance.

The influence strategy chosen by the champion depends upon to whom it is directed and factors associated with the situation in which it is used (Howell & Higgins, 1990). To influence superiors, rational justification is more likely, while assertiveness is more typical to influence subordinates. In formal situations, standard methods, such as feasibility analysis, cost-benefit analysis, and prototype presentations, are likely to be used. In informal settings, arguments not directly backed-up by formal analysis, but based on persuasive statements linking the technological innovation to the corporation's strategic plan are more common.

In their influence activities, champions draw upon many resources including internal and external information, material resources, political support (Beath, 1991), and cross-functional ties (Meador & Mahler, 1990; Shane, 1994). Information is necessary to justify the evaluation, selection, and promotion of the project. Material resources, including funding, personnel, and expertise, enable champions the means to gather information, assess the viability of potential projects, and implement the project. Political support enables momentum to continue, guaranteeing resource availability and rewards for successes or protection from negative consequences of failed projects. Cross-functional ties, achieved by building associations with related areas, allow coordination of activities across different functions necessary to the project. Equally important are links with service providers outside of the organization, such as vendors and consultants, to ensure the necessary resources can be secured. Although many organizations intentionally foster the activities of champions, their influence tactics are not always regarded in a positive light (Beath, 1991).

Visionary Perspective for Change

The project champion is sold on a project to the extent that he puts himself on the line, risking his own reputation, to see the project through. Rather than act as an idea generator, the champion serves as a visionary by evaluating circumstances and recognizing opportunities for change (Landers, 1999; Meredith, 1986). A recognition of the strategic direction of the organization, how to implement that strategy, and the responsibility for achieving those plans are inherent to the champion. Further, a sense of the potential benefits of the project, such as the opportunity for competitive advantage, the profitability to be reaped, or improvements in efficiencies, are foreseen by the champion (Beath, 1991; Landers, 1999; Mattei, 2001; Pinto & Slevin, 1989).

The champion not only formulates the vision for the project but directs his energies to bringing about change to achieve that vision (Landers, 1999). Primary among the influence strategies employed is persuasive communication (Sumner, 2000). The vision must be clearly communicated in simplistic terms and in a concise manner in order that others will immediately understand and support the vision (Kotter, 1995). Since substantial resources are devoted to ES projects, it is important that the implications of the new system be effectively communicated.

Vital Importance of the Role of Project Champions

It is evident that the role of project champion is vitally important, so important that in strategic use of IS for mission critical applications in particular, the literature suggests the project champion may be the most important development consideration (Beath, 1991; Hayes-Roth & Jacobstein, 1994; Martinsons, 1993; Sumner, 2000). The project champion can play the pivotal role in seeing the system through development, implementation, and use. At the completion of each of these stages is a reevaluation of the system. At these points, the champion can provide a significant degree of momentum (Sviokla, 1996). To gain an understanding of the importance of a project champion for the application of an ES for competitive advantage, the experiences of Ciba-Geigy are discussed in the next section.

CIBA-GEIGY'S EXPERT SYSTEM PROJECT

The Ciba-Geigy Corporation is an international chemical manufacturing firm headquartered in Basel, Switzerland. The Dyestuffs and Chemicals Division, one of ten divisions, represents approximately 20% of corporate sales. The division produces over 2,000 products including fabric dyes, optical brighteners, and industrial chemicals.

As a leading dyestuffs and chemicals producer, Ciba-Geigy recognizes the value of IT as an important means for gaining competitive advantage. Ciba-Geigy's orientation toward leading edge technology as a competitive weapon has enhanced the company's progressive image. In a survey of 31 chemical customers, Ciba-Geigy was perceived to provide the most effective state-of-the-art customer service systems.[1] Continually striving to gain market position by fostering their progressive image, Ciba-Geigy has emphasized the need to utilize IT in direct marketing. The use of IT by the sales force provides a highly visible means for projecting this image as well as enhancing sales force performance.

No formal planning process to identify IT opportunities had been established. However, the Corporate Management Committee, headed by the president and chief executive officer, communicated the need to redirect traditional ways of operating into more productive competitive channels by applying IT, among other technologies. Top management's support was communicated across the 10 corporate divisions via department meetings as well as management development programs.

The vice president (VP) of the Dyestuffs and Chemicals Division was the driving force towards sales force automation. Under his direction, sales personnel were equipped with laptop computers, facilitating rapid communication and inquiry with the division office at the point of customer interaction. Order entry, report submission, electronic mail, as well as other forms of communication are supported by dial-up connections between customer sites and the centralized processing systems. The implementation of communication-supported laptop technology is in line with the corporate strategy of competitively employing IT. This communication link is recognized as vital to successful implementation of ES (Beath, 1991; Tiwana & Balasubramaniam, 2001).

The use of laptops led to improved communication, in terms of such factors as speed, receipt and response, and content completeness, between the sales force and the division office. The VP capitalized on these outcomes by employing impression building (Howell & Higgins, 1990) to present a convincing vivid portrayal of the positive impacts realized (Mayhew, 1999). In various conversations with superiors, he mentioned the laptop initiative and claimed improved communications contributed to the ability to secure the division's business partnership with its customers, translating directly into business gains. Specifically, he explained that access to the online order processing inventory and sales service system enables sales representatives to complete a sales transaction more quickly, increasing employee productivity and providing more responsive and effective customer service. This taste of success led the VP to seek further improvement. In informal meetings with the corporation's computer vendor, IBM, the VP became convinced that customer support could be enhanced through the application of an ES, a recognized benefit of expert system applications (Mattei, 2001). The ES project champion emerged. As is necessary for an ES champion in particular, the VP had the necessary capability both to recognize the value of increasing the accessibility to an area of knowledge critical to serving customers and to manage that internal knowledge (Alavi & Leidner, 1999; Hansen et al., 1999; Zack, 1999).

The Development of the OpBright Expert System

In addition to the driving force of the project champion, a number of factors present within Ciba-Geigy set the stage for the development of an ES. An environment conducive to the champion's ES project greatly facilitates his ability to guide the project through to successful implementation (Mayhew, 1999). The factors contributing to ES development are presented in Table 1 and discussed below.

Table 1: Factors contributing to expert system development

1. **Emergence of Expert System Project Champion.**
   The VP of the Dyestuffs and Chemicals Division, already a driving force in the application of information technology, becomes convinced of the improved sales force support possible, for on-site customer product questions, through the application of expert system technology.

2. **Strategic Orientation Toward the Application of Information Technology.**
   Ciba-Geigy Corporation's strategic orientation emphasizes the application of state-of-the-art technology as a competitive resource to bolster the company's progressive image.

3. **Top Management Support.**
   Top management supports the corporate-wide use of information technology as a means of promoting the company's progressive image in applying leading edge technology.

4. **Formalized Information Dissemination.**
   Management development programs and department meetings served as formal means of disseminating the orientation toward the application of information technology for competitive advantage.

5. **Existing Platform.**
   An existing platform, in the form of the sales force's laptops, eliminated the need to acquire hardware dedicated to the ES.

6. **Appropriate Problem Domain.**
   The product recommendation made by a salesperson, based on the consideration of numerous factors specific to each customer's requirements, is critical to secure customer relationships for repeat business. Both the criticality and the rule orientation of this area of application make it an appropriate domain.

7. **Available Domain Expert.**
   An internal domain expert, with over 15 years of experience as a customer support technician and troubleshooter, was available and willing to participate in the ES development process.

Ciba-Geigy's strategic orientation emphasizes the application of state-of-the-art technology as a competitive resource to continually bolster the company's progressive image. Thus, top management supports the corporate-wide use of IT as a means of promoting the company's progressive image. This strategic objective is disseminated via formal mechanisms. In line with this strategic objective was the implementation of the sales force laptops. The presence of this platform improved the ease of communication and eliminated the need to acquire hardware specifically for an ES. Further support of the sales force focused on the area of product recommendations specific to each customer's requirements. Such support is critical to secure customer relationships for repeat business. Both the criticality and the rule orientation of this area of application make it an appropriate domain. Finally, an internal domain expert, with over 15 years of experience, was available and willing to participate in the ES development process.

Project Initiation

The VP had the insight to identify the importance of offering fast expert advice regarding the appropriate use of optical brighteners for individual customer's applications at the time of on-site sales calls. Optical brighteners are used for a wide variety of end-products. For textiles, paper products, and detergents, optical brighteners are applied to enhance coloring, i.e., to make "whites whiter and brights brighter." Non-textile applications include testing for leaks, such as those in automotive parts. Salespeople are thus required to make appropriate and specific recommendations concerning a wide range of applications, wherein the factors to consider can vary widely. In textile applications, for example, the fabrics may be of varying fiber, weave, weight, and content. Additionally, salespeople must be able to respond to maintenance requests such as, "Could this optical brightener be causing this type of fabric discoloration?" and "What should be done to correct for the discoloration?"

Since it is impossible for each salesperson to understand the impact every optical brightener has on the numerous applications, frequent calls are made to the company's technical expert. This adds lag time in responding to customer requests since the expert is not always available. The inability of a salesperson to answer customers' questions can result in delayed or lost sales. Recognizing this impact, the VP championed the project. Although he had neither extensive experience nor great awareness of the technology, common of project champions (Earl et al., 1988), he had the sense of potential profitability, a visionary characteristic held by project champions (Beath, 1991; Mayhew, 1999; Pinto & Slevin, 1989). In meeting with the MIS group, he enthusiastically presented his vision of increased sales profitability. He excitedly explained that sales representatives would more readily close sales because technical product expertise could be brought into customer interactions, allowing more farsightedness in decision making by the customer. So caught up in the VP's vision was the lead systems analyst, that he bypassed the backlog of development requests and agreed to begin the ES project. Such charismatic behavior, which captivates and draws others toward the champion's objectives, has empirically been found among the transformational leadership behaviors of champions (Howell & Higgins, 1990; Landers, 1999).

The Consideration of Costs and Benefits

As project champion, the VP recognized a number of potential benefits realizable from managing internal knowledge through the implementation of the ES. Included among these are gaining competitive advantage, faster response to customers, consistent quality customer service, training new salespeople, and managing product expertise, all of which are recognized benefits of astute management of corporate knowledge and expertise, as previously discussed. Table 2 lists these potential benefits, which are discussed below.

The use of OpBright on sales calls was seen as reinforcing Ciba-Geigy's competitively distinctive progressive image through the high visibility afforded by on-site customer interaction supported by an advanced technology. Individual customer questions could be addressed on the spot. Consistency and quality in responses could be achieved. Further, the sales force could develop a greater understanding of the technical aspects of their products. New salespeople could benefit by having unconstrained access to a "technical expert." The use of laptops in combination with dial-up connections to ES technology, was recognized by the VP, in accordance with his visionary perspective (Landers, 1999; Mayhew, 1999; Meredith, 1986), as providing the opportunity for enhanced distributed knowledge throughout the organization. The VP was able, through persuasive statements (Howell & Higgins, 1990; Mayhew, 1999; Sumner, 2000) and clear communication

Table 2: Potential benefits from the OpBright expert system

1.	**Gain competitive advantage** by fostering the leading edge company image resulting from the high visibility of sales force interaction with state-of-the-art technology at the customers' sites.
2.	**Respond more quickly to customers'** product selections and product questions.
3.	**Provide consistent quality customer service** via decisions and recommendations based on expert knowledge and experience.
4.	**Train new salespeople** by providing them with the OpBright expert system for both training sessions and sales calls.
5.	**Manage critical product expertise** by capturing, documenting, and distributing the expertise among company personnel.

(Kotter, 1995), to convince his superiors that this combination of technologies would further reinforce Ciba-Geigy's progressive image. He argued the division "must be prepared to be in the thick of the competitive fight by promoting [its] progressive image through the visible utilization of leading edge technology." He further claimed, "to meet the challenges of the future, [the division] must be willing to try new approaches."

Any discussion of benefits is incomplete without a consideration of costs. Costs and benefits for ES are particularly difficult to quantify (Hoplin & Erdman, 1990). The VP performed no formal cost/benefit analysis, rather he classified the development of the ES as a research and development (R&D) effort. Even for R&D projects, a formal analysis is recommended (Brenner & Tao, 2001). However, the cost of this first-time project was viewed as an investment in experience to be applied to future areas of application, an argument commonly made by champions in securing funding (Sharpe & Keelin, 1998). The VP was convinced that the impact of this technology would far outweigh the initial investment. In providing justification to his superiors, the VP relied on the classification of R&D project, for which formal no cost-benefit analysis, which could result in a "no-go" decision, was demanded. The use of a classification, such as R&D or experimental, is a common means for champions to gain approval for new technology (Martinsons, 1993). This rational justification, an influence strategy routinely employed by champions (Howell & Higgins, 1990), bypassed the necessity to undertake a cost-benefit analysis, satisfying his superiors, and allowed him to pursue his own agenda for the project.

In discussions with IBM, the VP secured 6 months of support in the form of both a support technician and installation on the mainframe of a license-fee-free ES shell. These incentives served to minimize the risk associated with devoting resources to new, untested waters. This "trial-period-freebie method" (Keyes, 1989, p. 37) is a common tactic used to sell the initiation of ES projects. Promoting the project through external vendor relationships to secure necessary resources is a typical influence activity of champions (Brenner & Tao, 2001; Earl et al., 1988). Specifically, the VP drew upon cross-functional ties with an external vendor, a recognized influence activity among champions (Meador & Mahler, 1990; Shane, 1994).

The Prototype System

The VP envisioned an entire family of ES, for all optical brightener applications would be developed in the future. Such vision is typical of champions, who often have insight into the potential for future extensions (Beath, 1991; Mayhew, 1999). What is specific to ES projects is the champion's ability to understand the areas of internal expertise which most benefit the organization. Among the areas, the VP identified fabric applications. The domain for the prototype ES was appropriately narrowed to include the application of optical brighteners to fabrics only. The prototype, programmed in ESE (Expert System Environment), IBM's ES shell, contains 71 rules, organized into 9 focus control blocks (FCB). FCBs, similar in concept to a programming language procedure, serve to organize the system's knowledge base as chunks of similar rules applicable in a particular context.

OpBright recommends a particular optical brightener product in response to a determination of an individual customer's needs. The ES user is initially prompted for the intended use of an optical brightener and the type of fabric to which it will be applied. Additional prompts solicit the properties of the fabric and application process. Sample screens are shown in Figure 1.

The Development Process

Although well informed on emerging technological trends, as is common for champions (Landers, 1999), the VP had only a surface understanding of ES technology. Thus he was not intimately involved in prototype development. Rather, he devoted his efforts toward overseeing the development process, which spanned about 8 weeks. The development team was comprised of four members. The first, the expert, provided the necessary knowledge concerning optical brightener product features and customer requirements to determine recommendations. This individual has extensive experience with the optical brightener product category, having served as a customer support technician and troubleshooter for over 15 years. The last three members included a systems analyst serving as knowledge engineer, a programmer, and a support technician supplied by IBM.

In informal interactions with the project team, the VP combined his leadership qualities of effective time management (Landers, 1999), inspirational behavior, and intellectual stimulation (Beath, 1991; Howell & Higgins, 1990; Landers). In following up on action items, he tracked the scheduled completion of each of the nine FCBs. To inspire the development team, he dropped in on meetings to communicate his excitement about the impact their work would ultimately have on enhancing and solidifying customer relationships. Expressing that he was truly amazed by their technological skills, he communicated his complete confidence in and admiration for their technological accomplishments. To stimulate them, he challenged them to integrate their exceptional and diverse talents to create a system that would distinguish Ciba-Geigy as the leader in state-of-the-art customer service systems.

Momentum Without a Project Champion

OpBright encountered a stalemate shortly after its completion. The VP was promoted and transferred to another out-of-state division. The incoming VP, in familiarizing himself with the division, reviewed each employee in terms of their management by objectives (MBO) statement. Only the two individuals who had worked to develop OpBright were provided with updated MBO statements. In this review, the OpBright expert system project objective was amended to reflect the intention of completing a prototype ES. Thus, the objective had been met; the prototype had been developed. These employees could now place their efforts on projects deemed to be of higher priority by the new division VP.

Figure 1: Sample interaction with the OpBright expert system

How is the product going to be used? (Choose one of the following:)	
?	Textile plants
	Laundry detergents, softeners, or carpet shampoos
	Used as a tracer or stain

What is the substrate? (Choose one of the following:)	
?	Cellulosic
	Wool
	Acrylic
	Acetate
	Polyester
	Nylon

What is the application process? (Choose one of the following:)	
?	Atmospheric exhaust
	High temperature exhaust
	Resin finish or Pad thermosol
	Peroxide bleach

What is the desired shade? (Choose one of the following:)	
?	Neutral blue to Blue
	Blue-violet

Product Recommendation is **UVITEX EBF** Additional Consultation Notes:	
1.	EBF is the recommended product
2.	It is suitable for atmospheric exhaust in any type of equipment
3.	The lightfastness of EBF is outstanding:
	40 hrs. of Xenon light and
	20 hrs. of Carbon Arc
To continue consultation, press ENTER	

The characteristics exhibited by the outgoing VP in achieving the development of OpBright could certainly be interpreted as simply those of an executive performing his job. However, previous research has shown that a project champion is frequently an executive from the area of application (Earl et al., 1988), using his leadership qualities to achieve that for which he has conviction (Beath, 1991; Landers, 1999). Further, the OpBright project brought unnecessary risk to the VP, who had already achieved success with the sales force laptop initiative. There was no pressing need for the VP to risk his reputation on emerging technology and tout it as having the highly visible capability to provide a competitive advantage. A project champion, however, would risk his reputation to see his vision through to completion (Meredith, 1986), tying his own personal success to project success (Mayhew, 1999).

Without a replacement project champion, OpBright remains at a standstill. The experiences of Ciba-Geigy certainly demonstrate that “if no one of high status and prestige in the implementing organization has any interest in pushing the [expert] system, then its chances of success are probably quite low” (Curley & Gremillion, 1983, pp. 207-8). Top management support is present; however, it is provided from the corporate level and exists in the broad sense of applying IT for competitive advantage. OpBright still resides on the division mainframe, but there are no mechanisms to promote its existence or provide assistance in using it. OpBright will most likely remain in the prototype stage indefinitely.

SUGGESTIONS TO AVOID AN ES PROJECT STALEMATE

Ciba-Geigy’s experiences reveal the impact a champion can have on ES development and what can occur when his support is lost. The ability of an organization to respond to changes in the environment is important to the success of the innovation (Kotter, 1995). Organizations can take action to avoid the pitfalls attributable to the departure of the ES project champion. In hindsight, the systems analyst and programmer offered their suggestions for avoiding the stalemate. Although these suggestions were not followed within Ciba-Geigy and are therefore not based on experience, they may provide insight for other organizations to act in a proactive manner. They are presented in Table 3 and discussed below.

Incorporate Expertise Management in Strategic Planning

A consideration of how valuable the champion’s ES application is must be made. As Beath (1991) pointed out, this is a key question for IT projects and requires applications be evaluated within the context of the overall organization. An assessment of areas of expertise critical to organizational processes and the potential for applying ES technology should be included within the strategic planning process. Expertise management thereby becomes a formalized managerial activity (Sipior &

Table 3: Suggestions to avoid the perils of losing the project champion

1.	Incorporate Expertise Management in Strategic Planning.
2.	Secure the Support of Top Management.
3.	Secure the Support of the Next Generation of Top Management.
4.	Recognize, Support, and Nurture a Project Champion.
5.	Formalize Project Measurement, Monitoring, and Follow-Up Evaluation.

Garrity, 1990). Incorporating expertise management in strategic planning is clearly unique to ES in particular, which differentiates ES project champions from champions of technological innovations in general.

Secure the Support of Top Management

It is well recognized that securing the support of top management is a prerequisite to the long-term success of ES projects (Braden, Kanter & Kopcso, 1989; Leonard-Barton & Sviokla, 1988; Meyer & Curley, 1989; Sipior & Volonino, 1991; Wong, 1996). Broad support for technological innovation from the top individual alone is insufficient unless it is translated into support for specific applications of ES technology by management levels below him.

Top management support is more likely if the ES fits with corporate strategy. By incorporating expertise management within strategic planning, this fit becomes more likely (Zack, 1999). In turn, this fit will garner broader organizational commitment (Meador & Mahler, 1990). To gain the necessary support, a results-oriented approach is preferable since it enables management to buy into the impact ES can have, rather than focusing on the technology itself (Sipior & Volonino, 1991). For management support to be ongoing (Hoplin & Erdman, 1990; Meyer & Curley, 1989), the results should have continued benefit.

Secure the Support of the Next Generation of Top Management

Top management support is not sufficient unless the support of the next generation of top management is secured (Kotter, 1995). If successors are ambivalent about the ES project, as was the case for Ciba-Geigy, they certainly will not take the initiative to understand this technology and maintain project momentum. Incorporating human expertise within IT can conjure up unrealistic images. As with any technology which has not yet gained widespread acceptance and use, an effort must be made to understand ES capabilities and clarify misconceptions.

Recognize, Support, and Nurture a Project Champion

The critical nature of the role of project champion has been well established. Therefore, the identification of the individual who demonstrates interest and enthusiasm for an ES project is important. As discussed, a project champion tends to emerge, rather than be assigned to the role. Evidence suggests both the inability to nurture such individuals as well as instances wherein this individual has been successfully developed (Schon, 1963). When a champion does not emerge naturally, a company may be able to "find or make a champion for the system" (Curley & Gremillion, 1983, p. 207).

In order for an ES champion to be developed, it is necessary to sell ES technology (Keyes, 1989). This could be achieved by forming a core support group (Meador & Mahler, 1990) whose purpose is to market the technology. This approach was employed at DuPont wherein an "internal artificial intelligence T&D [training & development] group offers a range of services: management-awareness speeches, four-hour management courses, and two-day intensive courses" (Keyes, 1989, p. 33). Through active involvement, an individual with interest and enthusiasm can be carefully harnessed to guide and promote an ES project (Sipior & Volonino, 1991). Another approach is to construct "portfolios of champions instead of portfolios of applications," (Beath, 1991) to formalize the planning process for innovative applications by placing the responsibility with individuals of champion caliber. This formalizes the role as part of an individual's job responsibilities and assures organizational support is ongoing (Hoplin & Erdman, 1990; Meyer & Curley, 1989).

Formalize Project Measurement, Monitoring, and Follow-Up Evaluation

Formalization of expert system project measurement, monitoring, and follow-up evaluation can improve the probability of project success (Brenner & Tao, 2001). Project measurement should include an evaluation of the phase of the project: (1) the validity of the technology to be employed in terms of delivering its claimed capabilities, (2) the benefits to be derived by its application, and (3) the products and services to be produced by employing the technology (Brenner & Tao). For each phase, project characteristics should be evaluated. The type of idea that generated the project could be rated from high of 3 to low of 0 for a technological advance, new or novel technology, new twist on a known technology, or no technological advance. Additional characteristics to consider include expertise and capabilities gained, time saved, R&D dollars saved, intellectual property expected from the project, importance of the project objective, commercial impact such as increased sales revenue, technical leverage, and internal and external relationship building. Changes in the project should be monitored as the project advances through each of the three stages. At project implementation, the estimates from the initial project evaluation should be compared to actual project performance data. Formalizing measurement, monitoring, and follow-up evaluation forces project accountability in terms of delivering the intended results.

CONCLUSION

The experiences of Ciba-Geigy demonstrate that "a 'system champion' can be a key contributor to implementation success" (Curley & Gremillion, 1983, pp. 203-4). A key variable associated with the success of technological innovations is the presence of a project champion (Howell & Higgins, 1990). Conversely, the loss of this individual can threaten the very existence of a project. Indeed, as Ciba-Geigy found out and had been warned, "lack of a project champion, or loss of one through job mobility, was identified with project failure" (Earl et al., 1988, p. 17). Organizations should thus take heed and devote attention to harnessing the enthusiasm and drive of ES project champions for advantage, before it is too late to preclude the loss of momentum generated by these individuals.

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ENDNOTE

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Chapter XX

Organizational Commitment in the IS Workplace: An Empirical Investigation of Its Antecedents and Implications

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Information systems (IS) technology has become a strategic resource for most organizations to compete successfully in today's highly uncertain marketplace. One critical component of this strategic resource is the IS human resource. Unlike many other professions, IS professionals historically displayed a much higher rate of turnover due to rapid technological changes, job stress and emerging employment opportunities. Such excessive turnover can be very costly to the organization in terms of costs of recruiting and retraining and the loss of systems development productivity. Therefore, maintaining a qualified and stable body of IS staff has been continually ranked among the most important issues for the successful functioning of IS departments. However, this important IS human resource management issue has not received enough empirical research attention within the IS management literature. The current study attempts to fill this gap by empirically examining the relationships among a set of organizational and psychological factors (i.e., management support, degree of IS control, IS strategic significance, role stressors) and the organizational commitment of IS managers. Empirical data was collected through large-scale questionnaire survey. The rigorous statistical method of LISREL path analysis was used. Results show that these variables are closely related to each other, which provides valuable insights for organizations to more effectively manage their IS human resource.

INTRODUCTION

Information systems (IS) technology is drastically changing every aspect of our lives as well as that of organizations. Organizations are increasingly dependent on IS technology to obtain market information, design and produce products, keep in contact with customers, and manage business operations (McGee & Prusak, 1993). The recent success of Internet-based electronic commerce technology has further integrated modern IS technologies into organizations' daily life (Timmers, 1999). Forrester Research (1998) estimates that U.S. business electronic commence will explode from $43 billion in 1998 to $1.3 trillion in 2003. In many industries, IS has emerged from a traditional supportive function to a strategic resource that may finally determine the firms' competitive capability (Sabherwal & King, 1995).

While the introduction of new IS technology offers strategic advantages to organizations, it may often incur negative effects on IS human resource management. For example, the widespread adoption of enterprise resource planning (ERP) systems requires companies to devote significant human resource to system implementation, support and maintenance (Callaway, 1999). Because of the complexity, high cost, limited project time-frame, and high expectations of ERP systems, IS personnel involved in the project are commonly under extreme pressure (Bingi, Sharma & Godla, 1999). Meanwhile, the introduction of such systems often requires reengineering the original IS structure through networking and downsizing (Benjamin & Levinson, 1993; Teng, Grover & Fiedler, 1994). These changes, coupled with the increased knowledge, awareness and demands of IS users, have considerably altered IS professionals' work environment, thus creating the potential for increased job stress (Thong & Yap, 2000). Job stress in turn profoundly alters IS staff's commitment to the organization and their motivation to stay with the organization (King & Sethi, 1997).

Maintaining a qualified and stable body of IS staff has been continually ranked among the most critical factors for successful functioning of IS departments (Brancheau, Janz & Wetherbe, 1996; Terry, 2001). However, it is shown that the turnover rate among IS professionals is consistently high and often exceeds 20% (U.S. Department of Commerce, 1997), which results in a turnover of almost half the IS personnel every 2 years. To organizations, such excessive turnover can be very costly in terms of costs of recruiting and retraining, loss of systems development productivity, lower staff morale, and erosion of corporate memory (Igbaria, Meredith & Smith, 1994; Lee, 2000). Experts estimate that it can cost as much as two and a half times an employee's salary to replace him or her considering all tangible and intangible costs (Terry, 2001). While the difficulty of the retention of qualified personnel cannot be understated, a particular problem in the retention of IS personnel is attributed to their "higher growth needs," which makes the efforts involved in motivating IS personnel quite substantial (Couger & Zawacki, 1980; Igbaria, Greenhaus & Parasuraman, 1991; Lee, 2000).

Although these and similar issues have been addressed in the organizational behavior literature, the human resource management issues relating to IS professionals have not received enough research attention within the IS literature (Ginzberg & Baroudi, 1988; Sethi, Barrier & King, 1999). As Baroudi and Ginzberg (1986) already pointed out, there is considerable interest in understanding how to increase IS personnel productivity, satisfaction, and organizational commitment and to decrease turnover. Given the importance of retaining qualified IS personnel, studies directed at gaining further understanding of the factors that influence the turnover and commitment of IS personnel would contribute to the theoretical IS literature and also have practical significance. The purpose of this study is to address the above identified gap in the IS literature.

The next section reviews the research on organizational commitment, both in the organizational behavior and the IS literature. A theoretical framework is then developed along with a discussion of variables of interest. This is followed by hypothesized relationships of antecedent variables to organizational commitment of IS managers. Finally, the research methodology and analysis of results are presented, followed by discussions and implications of findings.

THEORETICAL FRAMEWORK

The organizational behavior literature has identified job stress and organizational commitment to be significant predictors of employee turnover (Currivan, 1999; Shore & Martin, 1989; Williams & Hazer, 1986). Glisson and Durick (1988) summarized that variables that contribute to organizational commitment can be divided into three groups: (1) variables that describe characteristics of the workers who perform the tasks (individual variables); (2) variables that describe characteristics of the jobs or tasks performed by the workers (job-related variables); and (3) variables that describe characteristics of the organization in which the tasks are performed (organizational variables).

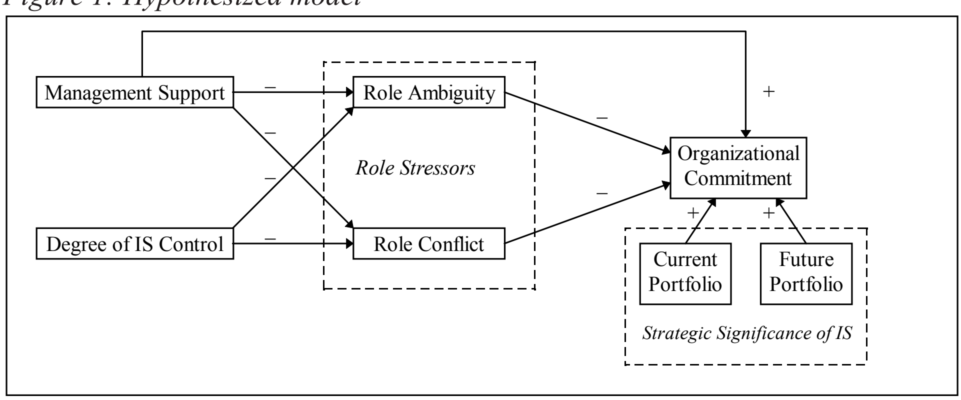
The relationships among these variables and organizational commitment have been well researched in organizational behavior theory (Mathieu & Zajac, 1990). Several conceptual models linking organizational commitment to a variety of individual, job-related, and organizational variables have also been proposed in the organizational behavior literature (Cotton & Tuttle, 1986; Gaertner, 1999). The IS literature, however, has not thoroughly studied the specific impact of variables from all three categories. After a thorough review of twelve occupational stress models, Thong and Yap (2000) summarized nine key points for IS occupational stress and commitment research, one of which is that both individual-level and organizational-level variables must be carefully studied to avoid incomplete understanding of the phenomenon.

The existing few IS human resource management research studies focused primarily on the effects of individual and job-related variables on the organizational commitment and turnover of IS personnel. For example, Baroudi (1985) examined the impact of boundary spanning (job-related variables) and role stressors (individual variables) on IS personnel organizational commitment and turnover. A study by Igbaria and Greenhaus (1992) tested the effects of demographic variables (age, education, etc.; individual variables), role stressors (role conflict and role ambiguity; individual variables), and career-related variables (salary, promotability; job-related variables) on the organizational commitment of IS personnel. A more recent study by Lee (2000) further studied the moderating effects of growth need strength, another important but individual level variable. Given the constant change and high pressure in the IS working environment as discussed earlier, more empirical research attention on IS organizational variables is warranted.

The current study develops a path analytic model by integrating variables from all three categories. It extends the organizational behavior research into the IS management area by examining the linkages between management support, degree of IS control, IS personnel role ambiguity, role conflict, strategic significance of IS, and organizational commitment of IS managers. The hypothesized model under investigation is depicted in Figure1.

In Figure 1, management support and degree of IS control are considered as organizational (group 1) variables, and strategic significance of IS as a job-related (group 2) variable, while role stressors are considered as individual (group 3) variables. The current study does not include some antecedent variables originally proposed in the meta-analysis by Mathieu and Zajac (1990) because this is only part of a major research project. For example, job satisfaction is commonly cited as antecedent to commitment. However, considering that the effects of job satisfaction have been well studied in both the organizational behavior literature (Netemeyer, Burton & Johnston, 1995) and the IS literature (Igbaria & Guimaraes, 1993), and

Figure 1: Hypothesized model



recent studies also show that there's no significant causal relationship between job satisfaction and commitment (Currivan, 1999), hence the job satisfaction variable was not included in the major research framework. The variables included in the hypothesized model are defined as follows:

1. *Management Support*: the degree to which top management understands the importance of IS, creates a supportive environment for IS, and involves in the activities of IS function (Raghunathan & Raghunathan, 1988).
2. *Degree of IS Control*: the degree to which IS function has control over IS through formalization and standardization of rules and procedures and through authority of decision making concerning IS activities (Cash, McFarlan, McKenney & Apoplegate, 1992).
3. *Strategic Significance of IS*: the degree to which IS activities are vital to the firm's daily operation, product innovation, and competitive capabilities (Raghunathan & Raghunathan, 1990). According to Cash et al. (1992), IS strategic significance can be viewed from two dimensions, i.e., strategic significance of existing IS (Current Portfolio) and strategic significance of IS under development (Future Portfolio).
4. *Role Stress*: traditionally consists of two elements (Rizzo, House & Lirtzman, 1970)
   - Role Conflict*: the degree to which individuals encounter incompatible job demands or expectations from their role partners (e.g., peers, management,customers) that cannot be satisfied simultaneously.*
   - Role Ambiguity*: the degree to which individuals have inadequate knowledge or information with which to perform their jobs.*
5. *Organizational Commitment*: the degree of an individual's willingness to stay or propensity to leave his or her organization. It includes a strong belief in and acceptance of the organization's goals and values, a willingness to exert considerable effort on behalf of the organization, and a definite and strong desire to maintain membership in the organization (Mowday, Porter & Steers, 1982).

HYPOTHESES DEVELOPMENT

Effects of Management Support

Management Support and Organizational Commitment. The elationship between management support and organizational commitment is well documented in the organizational behavior literature, as supportive leadership has significant positive impact on an individual's commitment to the organization. Glisson and Durick (1988) verified that supportive leader behavior in the form of leader consideration is an excellent predictor of organizational commitment. Leader consideration refers to the consideration of a supervisor for subordinate's feelings, problems, and input for decisions. A longitudinal study by Majchrzak and Cotton (1988) verified that supportive managerial environment has significant positive impact on individuals' organizational commitment. In a meta-analysis of the antecedents of organizational commitment, Gaertner (1999) found significant positive relationship between supervisor support and organizational commitment. A recent study by Currivan (1999) also confirmed that greater supervisor support produces greater organizational commitment.

In the IS literature, management support has been consistently identified as a key positive factor in influencing the success of many IS-related activities (King, Grover & Hufnagel, 1989; Raghunathan & Raghunathan, 1988). IS managers perceive such support as an indicator of top management's confidence in the ability of IS to help meet organizational goals. A supportive managerial attitude would provide IS executives with an environment in which they believe that their work will be recognized and appreciated and thus is more likely to motivate them to be committed to the organization. Mak and Sockel (2001) confirmed that management support of IS personnel career development is a more important indicator than job satisfaction for motivating IS employees to stay with the organization. Therefore, it is hypothesized that:

H1: Management support has direct positive effects on the organizational commitment level of IS managers.

Management Support and Role Conflict, Role Ambiguity. A supportive management may help individuals to clarify their objectives and management expectations, thus reducing the level of role conflict and role ambiguity. In a meta-analysis of 96 studies on role ambiguity and role conflict, Jackson and Schuler (1985) verified that leader consideration has significant negative correlation with role conflict and role ambiguity. Glisson and Durick (1988) further confirmed the above relationship based on an empirical study of 319 employees in 22 organizations. Majchrzak and Cotton (1988) also found that supportive managerial environment is an effective way of reducing role stress during the adjustment to technological change. Similarly, in their study about the antecedents and consequences of role stress, Schaubroeck, Cotton and Jennings (1989) found social support to be a significant predictor of both lower role conflict and role ambiguity. Thong and Yap (2000) also concluded that social support, including the support from supervisors, colleagues, friends, relatives and spouse, is one of the key factors in reducing IS occupational role stress. Therefore, it is hypothesized that:

H2a: Management support has direct negative impact on the level of role conflict of IS managers.

H2b: Management support has direct negative impact on the level of role ambiguity of IS managers.

Effects of Degree of IS Control

Degree of IS Control and Role Conflict, Role Ambiguity. Nicholson and Goh (1983) found significant negative relationship between formalization, participation in decision making (PDM) and role conflict and role ambiguity. A causal model proposed by Jackson (1983) identified PDM as a primary factor for reducing role conflict and role ambiguity. The meta-analysis on role stress by Jackson and Schuler (1985) indicates that formalization and participation can help reduce role conflict and role ambiguity. Michaels, Cron, Dubinsky and Joachimsthaler (1988) also found that formalization has direct negative effect on role conflict and role ambiguity of salespeople. Schaubroeck et al. (1989) found participation to be a significant antecedent variable of lower role ambiguity using covariance structure analysis.

With the increasing popularity of end-user computing, the IS function tends to lose control over IS activities in some organizations. While the literature suggests that increasing user control may lead to better IS usage, the lack of IS control can also cause problems to the organization, such as lack of standardization and data hygiene (Cash et al., 1992). Yet another often overlooked but important problem is that the degree of IS control, in the forms of standardization, formalization, and authority over IS decision making, may significantly influence the role conflict and role ambiguity of IS personnel. IS executives who feel that they are losing control over IS activities are likely to be subject to feelings of frustration and loss of power, resulting in higher levels of role stress. Lim and Teo (1999) found the feeling of losing control over the system because of poor system maintenance to be an important source of IS personnel role stress. Therefore, it is hypothesized that:

H3a: Degree of IS control has direct negative impact on the level of role conflict of IS managers.

H3b: Degree of IS control has direct negative impact on the level of role ambiguity of IS managers.

Since previous literature already verified that formalization and participation in decision making have no direct effects on organizational commitment (Michaels, et al., 1988; Schaubroeck et al., 1989) but have indirect influence through role stressors, thus this study did not hypothesize a direct path from degree of IS control to organizational commitment.

Effects of Strategic Significance of IS

Cash et al. (1992) have proposed that the strategic significance of an organization's IS can be captured by the strategic significance of the portfolio of systems applications currently in operation and the portfolio of systems applications to be developed for the future. The positioning of IS along each of these two dimensions indicates the current and future importance of IS to the organization. This study uses current portfolio and future portfolio to represent these two dimensions of IS strategic significance.

IS Strategic Significance and Organizational Commitment. An important aspect of commitment is the definite desire of personnel to maintain organizational membership. IS managers are expected to maintain their ties to the organization if they feel higher levels of personal importance, self-achievement and task significance that their organizational role likely brings them. Steers (1977) first found that an individual's sense of personal importance to the organization and need for achievement positively affect commitment. In their book about the psychology of commitment, Mowday et al. (1982) also stated that perceived personal importance is one of the most important antecedents of organizational commitment. That is, when employees felt that they were needed or important to the organization's mission, commitment attitudes increased. Moreover, an empirical study by Glisson and Durick (1988) found significant positive relationship between task significance and organizational commitment. In their comprehensive meta-analysis of the antecedents, correlates, and consequences of organizational commitment, Mathieu and Zajac (1990) also confirmed that such job characteristics as challenge, significance, and enrichment have significant positive relationship with organizational commitment. In the IS literature, Lee (2000) found that motivating potential of a job (a summary index of task identity, task significance, autonomy, feedback and skill variety) has significant negative relationship with an IS professional's turnover intention. It is therefore hypothesized that:

H4a: The strategic significance of current portfolio has direct positive effect on the level of organizational commitment of IS managers.

H4b: The strategic significance of future portfolio has direct positive effect on the level of organizational commitment of IS managers.

Effects of Role Stressors

Role Stress and Organizational Commitment. This is one of the most widely studied relationships in organizational behavior literature, where this core relationship of the current hypothesized model has been validated. These relationships, though important for effective management of IS organization, have not been well researched in IS literature except for the Igbaria and Greenhaus (1992) and King and Sethi (1997) studies. The current study will be an attempt to address this important IS human resource management issue using a large sample of IS managers.

It is generally proposed in the existing literature that role conflict and role ambiguity lead to higher psychological strain, thus reducing the individual's willingness to stay with the organization. An early meta-analysis (Fisher & Gitelson, 1983) of 43 studies on role conflict and ambiguity found organizational commitment to be the number one negative correlate of role conflict and role ambiguity. Based on data collected from a sample of 577 medical center employees, Brooke, Russell and Price (1988) found that role stress has significant negative relationship with organizational commitment using confirmatory factor analysis within LISREL framework. Jamal (1990) found the same negative relationship between role stressors and organizational commitment from a sample of 215 nurses. A meta-analysis by Brown and Peterson (1993) further confirmed that role conflict and role ambiguity have significant negative effects on salesperson organizational commitment.

More recently, Netemeyer et al. (1995) used LISREL path analysis and found that role ambiguity and role conflict both have negative effects on organizational commitment. In the IS literature, Sethi et al. (1999) confirmed the significant positive relationship between role stressors and IS professional burnout, while burnout negatively impacts organizational commitment. In summary, the following hypothesis can be made:

H5a: Role conflict has direct negative impact on the level of organizational commitment of IS managers.

H5b: Role ambiguity has direct negative impact on the level of organizational commitment of IS managers.

The above review and discussion of literature has been summarized in Table 1.

Table 1: Literature basis of the hypothesized path-analytic model

Relationships studied in this paper	Relationships described in previous literature	Nature of relationships
Management Support and OC	Leadership - OC (Glisson & Durick, 1988) Supportive managerial environment - OC (Majchrzak & Cotton, 1988) Supervisor support - OC (Currivan, 1999; Gaertner, 1999) Management Support of career development - motivation to stay (Mak & Sockel, 2001)	Significant Positive Relationship
Management Support and RC, RA	Leader initiating structure, Leader consideration - RC,RA (Jackson & Schuler, 1985) Leadership - RC, RA (Glisson & Durick, 1988) Supportive managerial environment - RC, RA (Majchrzak & Cotton, 1988) Social support - RC, RA (Schaubroeck et al., 1989) Social support - RC, RA (Thong & Yap, 2000)	Significant Negative Relationship
Degree of IS Control and RC,RA	Formalization, PDM - RC, RA (Nicholson & Goh, 1983) PDM - RC, RA (Jackson, 1983) Formalization, Participation (Jackson & Schuler, 1985) Formalization - RC, RA (Michaels et al., 1988) Participation - RA (Schaubroeck et al., 1989) Feeling of losing control - Role stress (Lim & Teo, 1999)	Significant Negative Relationship
IS Strategic Significance and OC	Perceived personal importance, Need for achievement - OC (Steers, 1977) Personal importance (Mowday et al., 1982) Task significance - OC (Glisson & Durick, 1988) Job characteristics - OC (Mathieu & Zajac, 1990) Motivation potential of job - Turnover intention (Lee, 2000)	Significant Positive Relationship
RC, RA and OC	RC, RA - OC (Fisher & Gitelson, 1983) Role stress - OC (Brooke et al., 1988) RC, RA - OC (Jamal, 1990) RC, RA - OC (Igbaria & Greenhaus, 1992) RC - OC (Brown & Peterson, 1993) RA - OC (Netemeyer et al., 1995) RC, RA - OC (King & Sethi, 1997) RC, RA - OC (Sethi et al., 1999)	Significant Negative Relationship

OC - Organizational Commitment PDM - Participation in Decision Making
RC - Role Conflict RA - Role Ambiguity

RESEARCH METHODOLOGY

Data Collection

A self-administered questionnaire was mailed to 800 information systems executives chosen at random from a list of 3,000 senior IS executives. This list of 3,000 names was obtained from the "directory of top IS executives" database maintained by Applied Computer Research, Inc. This subset was selected at random from its list of senior IS executives in more than 10,000 different organizations all around the U.S., thus representing all types of organizations, industries, corporate cultures and geographic areas. There were 237 responses, of which 231 were complete and hence usable. The response rate is about 29%, which is considered to be satisfactory. Table 2 provides an industry classification of the sample companies and Table 3 presents information on company revenues. Companies with revenues of 50 million and above are well represented (85%) in this sample. The results of this study may therefore be more appropriately relevant to companies in these size categories. Manufacturing and finance sectors are represented by 57% of the sample. This information is relevant while generalizing the results of this study.

Table 2: Type of companies in the sample

Industry Type	Number of Respondents
Business Services	7
Finance/Insurance	52
Government	3
Manufacturing	86
Medicine/Law/Education	10
Petroleum	5
Public Utility	12
Transportation	10
Wholesale/Retail	22
Others	24
Total	231

Table 3: Company sales (millions of $)

Sales	Number of Respondents
Less than 100 M	51
100 to < 250 M	33
250 to < 500 M	25
500 to < 1000 M	43
1000 M and above	57
Others (Sales not marked)	22
Total	231

Measurement Instruments

All variables in the current study are measured with multiple items on 5-point Likert scale ranging from “strongly disagree” to “strongly agree.” The items representing the variables are listed in Appendix A. The mean value of the multiple items representing the variable is considered as the value of that variable. Negatively worded questions are appropriately recoded.

Management Support was measured by 7 items developed from the management leadership and IS management literature (Raghunathan & Raghunathan, 1988, 1990). Representative items include “Top management involvement with IS function is strong” and “Top management understands the importance of IS function.”

Degree of IS Control was measured by 5 items developed from the organizational behavior and IS strategic planning literature. Specific references were made to the concepts of “IS dominance” and “User dominance” (Cash et al., 1992). Typical items include “There is lack of standardization and control over data hygiene” and “IS feels it is losing control over IS activities to users.”

Role Conflict and Role Ambiguity were measured, respectively, by 5 and 6 items adopted from the widely accepted Job-Related Strain index developed by Rizzo et al. (1970).

Current Portfolio and Future Portfolio dimensions of IS strategic significance were operationalized using multiple items modeled after the illustrative questions presented in Cash et al. (1988) and adapted by Raghunathan and Raghunathan (1990).

Organizational Commitment was measured using the short version of the organizational commitment questionnaire (OCQ) developed by Mowday et al. (1982), which is used extensively in the organizational behavior literature.

Scale Reliability and Validity

To ensure the content validity of the instrument items, the draft questionnaire was first read to two IS researchers who checked the items for appropriateness and relevance. Two IS executives of major organizations were then requested to complete the questionnaire and comment on the clarity and appropriateness of the items. Modifications were made to the final questionnaire based on their comments. Table 4 reports means, standard deviations, and reliability values for each of the variables. The reliability values based on Cronbach’s alpha are all 0.8 and above, which are well above the recommended minimum value of 0.7 (Nunnally, 1978).

The LISREL Path Analysis Procedure

The primary analytic technique in the current study is path analysis. The hypothesized model depicted in Figure 1 was tested using structural equation modeling (SEM), a second-generation multivariate technique that has gained increasing popularity in the last decade. The linear structural relations (LISREL) statistical software package was used for structural equation modeling purposes. Using the correlation matrix as input to the program, we analyzed the variance-covariance matrices and estimated the path coefficients of the specified model with maximum likelihood method. The input correlation matrix is presented in Table 5.

As can be observed from the correlation matrix, the data support the hypothesized directions of all relationships in the current study.

Though all the seven variables considered in this study have been developed and validated in earlier research, we tested the LISREL measurement models of the seven variables again to ensure the convergent and discriminant validity of the measurement instruments used in this study. The results, including item loadings, major fit indices and amount of variances explained are listed in Appendix B. As can be seen, all LISREL measurement modeling results are satisfactory, indicating good instrument validity.

PATH ANALYSIS RESULTS

The results of the path analysis are shown in Table 6. The table lists all nine hypothesized relationships, directions, path coefficients, and their t-values.

As can be seen from Table 6, two of the nine hypothesized paths are non-significant, i.e., the direct negative effect of management support on role conflict (Hypothesis H2a) and the direct positive effect of current portfolio on organizational commitment (Hypothesis H4a). The possible implications of these findings will be discussed later.

There is no single statistical test that best describes the strength of a structural equation model's prediction power. Rather, several measures may be used to assess its goodness-of-fit. In LISREL models, these measures may be divided into three

Table 4: Statistical attributes of scales used in the research

Variables	Number of Items	Mean	Standard Deviation	Reliability
Management Support	7	3.51	0.87	0.91
Degree of IS Control	5	3.65	0.81	0.84
Role Conflict	5	2.74	0.69	0.81
Role Ambiguity	6	2.55	0.70	0.82
Current Portfolio	6	4.44	0.63	0.89
Future Portfolio	9	3.47	0.55	0.84
Organizational Commitment	8	4.07	0.61	0.87

Table 5: Correlation matrix of variables in the model

Variables	X1	X2	X3	X4	X5	X6	X7
Management Support (X1)	1						
Degree of IS Control (X2)	0.34	1					
Role Conflict (X3)	-0.15	-0.36	1				
Role Ambiguity (X4)	-0.43	-0.35	0.35	1			
Current Portfolio (X5)	0.34	0.24	-0.12	-0.31	1		
Future Portfolio (X6)	0.27	0.06	-0.03	-0.26	0.35	1	
Organizational Commitment (X7)	0.38	0.34	-0.43	-0.37	0.32	0.36	1

Table 6: Path-analytic results of the hypothesized model

Variables	Predictor Variables	Hypothesized Direction	Path Coefficients	t - Value
Role Conflict	Management Support	-	NS	0.15
	Degree of IS Control	-	-0.33	-4.85
Role Ambiguity	Management Support	-	-0.32	-4.99
	Degree of IS Control	-	-0.17	-2.69
Organizational Commitment	Management Support	+	0.23	3.75
	Role Conflict	-	-0.34	-6.26
	Role Ambiguity	-	-0.12	-2.00
	Current Portfolio	+	NS	0.09
	Future Portfolio	+	0.24	3.97

NS - nonsignificant

categories: measures of absolute fit, measures of incremental fit, and measures of parsimonious fit (Hair, Anderson, Tatham & Black, 1992).

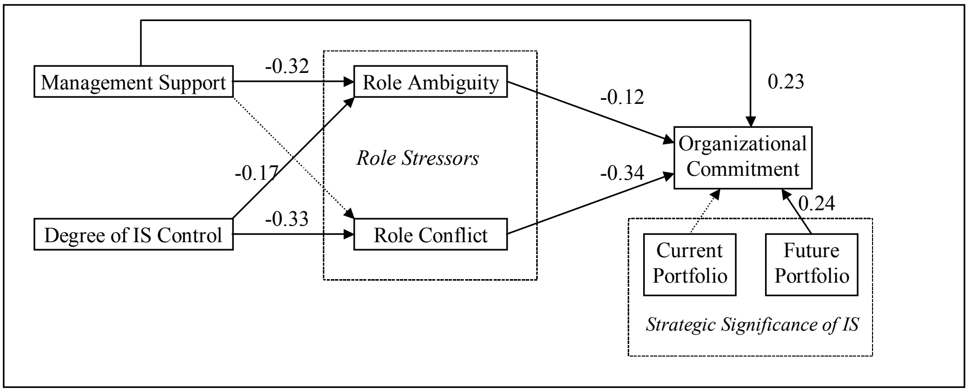
The measures of absolute fit include the Goodness-of-Fit Index (GFI) and Root Mean Square Residual (RMSR). GFI is a nonstatistical measure ranging in value from 0 (very poor fit) to 1 (perfect fit) that represents the overall degree of fit but is not adjusted for the degrees of freedom. RMSR is a measure of the average of the residuals between observed and estimated input matrices. Covariance or correlation matrices may be used for the input matrices (Dillon & Goldstein, 1984; Hair et al., 1992). Models with a RMSR score below 0.10 (Chau, 1997) are considered to be evidence of good fit.

Measures of incremental fit compare the proposed model to some baseline model, most often referred to as the null model (Bentler & Bonnet, 1980). The Normed Fit Index (NFI) and the Comparative-Fit-Index (CFI) are usually used for this purpose. NFI and CFI values greater than 0.90 are considered to be indicative of good model fit.

Finally, measures of parsimonious fit relate the goodness-of-fit model to the number of estimated coefficients required to achieve this level of fit. The Adjusted Goodness-of-Fit Index (AGFI) is often used to measure parsimonious fit. AGFI is an extension of GFI. It is adjusted by the ratio of the degrees of freedom for the proposed model to the degrees of freedom for the null model. GFI and AGFI values of 0.90 or more are considered evidence of good fit (Dillon & Goldstein, 1984; Hair et al., 1992).

The proposed LISREL structural model has excellent model fit, with GFI of 0.97, AGFI of 0.91, NFI of 0.91, CFI of 0.93, and RMSR of 0.061. All meet the recommended value. The final path-analytic model is depicted in Figure 2. The dotted lines represent nonsignificant paths. In summary, LISREL analysis supports Hypotheses H1, H2b, H3a, H3b, H4b, H5a, and H5b, while Hypotheses H2a and H4a are not supported.

Figure 2: The final path-analytic model



DISCUSSION

The results of the path analysis indicate that management support and future IS significance have direct positive impact on organizational commitment, while role conflict and role ambiguity have direct negative effects on organizational commitment. Moreover, management support and degree of IS control positively influence organizational commitment of IS managers indirectly through reducing role conflict and role ambiguity. These findings are consistent with those in organizational behavior and marketing management literature (Brown & Peterson, 1993; Mathieu & Zajac, 1990; Netemeyer, et al., 1995).

The results clearly demonstrated that an effective but very inexpensive way of improving IS professional retention is better management support structure, such as fostering a friendlier work environment, providing easier vertical communication, ensuring fair resource allocation, and allowing opportunities for personal growth. It is worth mentioning that peer support, although not included in the current study, is also a significant predictor of organizational commitment (Currivan, 1999).

The results show that role conflict and role ambiguity have direct negative effects on organizational commitment of IS professionals. IS personnel usually have to fulfill the requirements of many different parties including clients, supervisors and coworkers. But these requirements are often not clearly defined, which results in a tremendous amount of job stress that directly affects commitment. Therefore, when assigning tasks, IS management must pay close attention to the clarity of roles, responsibilities, objectives and priorities. In many cases, a carefully prepared proposal and plan of work are vital. Standardized procedures and policies can also be established to avoid some common conflicts and confusions.

The results also show that management support can help reduce role ambiguity, while its impact on reducing role conflict is not significant. Similar results were discussed in the meta-analysis of role ambiguity and role conflict by Jackson and Schuler (1985). That is, a supportive management may provide IS managers with more knowledge and information to clarify their roles, but the support is sometimes not enough to solve the problem of simultaneous role requirements on IS personnel from all over the organization. The management may appear to be supportive of IS activities in general, but it usually does not give enough attention to IS staff at the personal level to relieve them from role burdens. The management may sometimes even add on to this role burden by raising their expectations. Thus a significant implication from the current research is that management should take actions to support IS staff at the individual level to help them coordinate multiple role requirements. Also, it might be interesting for future research to look into the effects of different forms of management support on role stressors and organizational commitment.

The direct negative effect of degree of IS control on role stressors was confirmed in this study. That is, IS professionals want more control over the system to avoid unnecessary stress. While the popular trend of end-user computing calls for decentralization of information systems and user control, lack of IS control may result in poor system maintenance, loss of database integrity, and breach in system security, which are major sources of IS occupational stress (Lim & Teo, 1999). Therefore, when designing a company's IS infrastructure, management must give balanced consideration between IS control vs. user control and between centralization vs. decentralization.

The result that the significance of current IS has no significant impact on organizational commitment may indicate that IS managers associate career growth potential within the organization with the future importance of IS to the organization. Studies have found that IS professionals are generally satisfied, yet they demonstrate high turnover (Lee, 2000). While some of them use job-hopping as a way of boosting salary (Shachtman, 2000), many others with higher grow needs simply find the current system boring and non-challenging. Working with old legacy systems often makes IS professionals lose the opportunity to keep abreast of the latest technologies in the field. Therefore, it appears that continuous innovation and upgrading of the firm's information systems can not only give the firm new competitive capabilities but also enhance the commitment of IS personnel and meet their growth needs.

While the current study verified the important relationships among role stressors and commitment of IS managers, future studies should further look into the specific relationship between commitment and IS performance. Although the commitment-performance relationship has been extensively researched in general organizational and marketing management literature, similar studies are scarce under the IS management setting. Furthermore, this paper studied two factors affecting role stress of IS managers, i.e., management support and degree of IS control. It would be interesting for future research to examine the positive or negative impact of other factors on IS personnel role stress, such as improper learning curve assumption about IS from top management and lack of shared understanding about the role of IS between IS personnel and top management. Since this is a part of a major study, effects of some of the antecedent variables such as job satisfaction were not included in this study. This may be considered as one of the limitations and can be alleviated in a future, more comprehensive study.

CONCLUSION

The IS profession is generally quite stressful, but there is little theoretical or empirical research on the effect of occupational stress on IS professionals (Thong & Yap, 2000). The IS human resource management issues, such as job stress, tension, job satisfaction, commitment, and turnover, have long been overlooked in IS management literature. However, these issues are closely related to the psychological and physical well-being of the IS personnel and may become very costly to the organization if not managed properly. The current study tries to extend the research findings in organizational behavior literature to the IS management setting and investigated the relationships among management support, degree of IS control, IS strategic significance, role stressors, and organizational commitment of IS managers using path analysis. The results of this study demonstrate that these variables are closely related to each other. We believe that the empirical findings of the current study will contribute to the IS human resource management literature and provide valuable insights for organizations to more effectively manage their IS personnel and enhance IS performance.

APPENDIX A: QUESTIONNAIRE ITEMS

Management Support

MS1: Top management involvement with IS function is strong
MS2: Top management is interested in IS function
MS3: Top management understands the importance of IS function
MS4: Top management supports the IS function
MS5: Top management considers IS as a strategic resource
MS6: Top management understands IS opportunities
MS7: Top management keeps the pressure on operating units to work with IS

Degree of IS Control

IC1: IS feels it is losing control over IS activities to users
IC2: There is unplanned growth in the number of new systems and supporting staff
IC3: IS support services are delivered to users by multiple suppliers without coordination
IC4: There is lack of standardization and control over data hygiene and system
IC5: There is lack of standardization and control over systems

Strategic Significance

Current Portfolio
CP1: **IS** is vital to our organization
CP2: **IS** breakdown for extended periods will affect our organizational activity severely
CP3: Our company relies heavily on **IS** for efficient operation
CP4: **IS** breakdown will critically affect one or more of our functional departments
CP5: **IS** breakdown will affect our database access
CP6: **IS** breakdown will affect overall coordination within our organization

Future Portfolio
FP1: Projects involving applications of new technologies
FP2: Projects focusing on routine maintenance to meet evolving business needs, new regulatory or legal requirements
FP3: Projects focusing on existing systems enhancements
FP4: Projects whose primary benefit is providing new decision support information to top management
FP5: Projects whose primary benefit is providing new decision support information to middle and lower levels of management
FP6: Projects which allow the firms to develop and offer new products or services for sale
FP7: Projects which enable development of new administrative control and planning process

FP8: Projects which offer significant tangible benefits through improved operational efficiencies (e.g., reducing inventory)
FP9: Projects which appear to offer new ways for company to compete (e.g., fast delivery)

Organizational Commitment

OC1: I am willing to put in a great deal of effort beyond that normally expected in order to help this organization be successful
OC2: I talk up this organization to my friends as a great organization to work for
OC3: I find my values and organization's values are very similar
OC4: I am proud to tell others that I am part of this organization
OC5: This organization really inspires the very best in me in the way of job performance
OC6: I am extremely glad that I chose this organization to work for over others I was considering at the time I joined
OC7: I really care about the fate of this organization
OC8: For me this is the best of all possible organizations for which to work

Role Stress

Role Conflict

RC1: I often get involved in situations in which there are conflicting requirements
RC2: I often am asked to do things that are against my better judgment
RC3: I often receive an assignment without adequate resources and materials to execute it
RC4: I often have to buck a rule or policy in order to carry out an assignment
RC5: I often receive incomplete requests from two or more people

Role Ambiguity

RA1: I feel certain about how much authority I have
RA2: There are clear planned goals and objectives for my job
RA3: I often know that I have divided my time properly
RA4: I often know what my responsibilities are
RA5: I often know exactly what is expected of me
RA6: Explanation is always clear of what has to be done

APPENDIX B : LISREL MEASUREMENT MODELING RESULTS

<table>
<tr><th colspan="2">Variables</th><th>Item Loading</th><th>Amount of Variances Explained</th><th>GFI</th><th>NFI</th><th>CFI</th><th>RMSR</th></tr>
<tr><td rowspan="7">Management Support</td><td>MS1</td><td>0.78</td><td rowspan="7">One factor explained 66.2% of variance</td><td rowspan="7">0.89</td><td rowspan="7">0.90</td><td rowspan="7">0.91</td><td rowspan="7">0.053</td></tr>
<tr><td>MS2</td><td>0.77</td></tr>
<tr><td>MS3</td><td>0.81</td></tr>
<tr><td>MS4</td><td>0.81</td></tr>
<tr><td>MS5</td><td>0.79</td></tr>
<tr><td>MS6</td><td>0.67</td></tr>
<tr><td>MS7</td><td>0.71</td></tr>
<tr><td rowspan="5">Degree of IS Control</td><td>IC1</td><td>0.50</td><td rowspan="5">One factor explained 61.1% of variance</td><td rowspan="5">0.95</td><td rowspan="5">0.94</td><td rowspan="5">0.95</td><td rowspan="5">0.055</td></tr>
<tr><td>IC2</td><td>0.53</td></tr>
<tr><td>IC3</td><td>0.75</td></tr>
<tr><td>IC4</td><td>0.85</td></tr>
<tr><td>IC5</td><td>0.83</td></tr>
<tr><td rowspan="6">Current Portfolio</td><td>CP1</td><td>0.66</td><td rowspan="6">One factor explained 65.3% of variance</td><td rowspan="6">0.96</td><td rowspan="6">0.96</td><td rowspan="6">0.97</td><td rowspan="6">0.033</td></tr>
<tr><td>CP2</td><td>0.81</td></tr>
<tr><td>CP3</td><td>0.74</td></tr>
<tr><td>CP4</td><td>0.82</td></tr>
<tr><td>CP5</td><td>0.83</td></tr>
<tr><td>CP6</td><td>0.68</td></tr>
<tr><td rowspan="9">Future Portfolio*</td><td>FP1</td><td>0.74</td><td rowspan="3">Factor 1 explained 26.0% of variance</td><td rowspan="9">0.96</td><td rowspan="9">0.96</td><td rowspan="9">0.98</td><td rowspan="9">0.039</td></tr>
<tr><td>FP6</td><td>0.75</td></tr>
<tr><td>FP9</td><td>0.87</td></tr>
<tr><td>FP4</td><td>0.81</td><td rowspan="4">Factor 2 explained 31.9% of variance</td></tr>
<tr><td>FP5</td><td>0.83</td></tr>
<tr><td>FP7</td><td>0.78</td></tr>
<tr><td>FP8</td><td>0.78</td></tr>
<tr><td>FP2</td><td>0.74</td><td rowspan="2">Factor 3 explained 18.5% of variance</td></tr>
<tr><td>FP3</td><td>0.88</td></tr>
<tr><td rowspan="8">Organizational Commitment</td><td>OC1</td><td>0.55</td><td rowspan="8">One factor explained 53.6% of variance</td><td rowspan="8">0.94</td><td rowspan="8">0.93</td><td rowspan="8">0.95</td><td rowspan="8">0.050</td></tr>
<tr><td>OC2</td><td>0.76</td></tr>
<tr><td>OC3</td><td>0.68</td></tr>
<tr><td>OC4</td><td>0.82</td></tr>
<tr><td>OC5</td><td>0.62</td></tr>
<tr><td>OC6</td><td>0.75</td></tr>
<tr><td>OC7</td><td>0.51</td></tr>
<tr><td>OC8</td><td>0.73</td></tr>
<tr><td rowspan="5">Role Conflict</td><td>RC1</td><td>0.62</td><td rowspan="5">One factor explained 57.6% of variance</td><td rowspan="5">0.97</td><td rowspan="5">0.96</td><td rowspan="5">0.97</td><td rowspan="5">0.038</td></tr>
<tr><td>RC2</td><td>0.81</td></tr>
<tr><td>RC3</td><td>0.76</td></tr>
<tr><td>RC4</td><td>0.61</td></tr>
<tr><td>RC5</td><td>0.62</td></tr>
<tr><td rowspan="6">Role Ambiguity</td><td>RA1</td><td>0.62</td><td rowspan="6">One factor explained 52.9% of variance</td><td rowspan="6">0.97</td><td rowspan="6">0.95</td><td rowspan="6">0.97</td><td rowspan="6">0.040</td></tr>
<tr><td>RA2</td><td>0.66</td></tr>
<tr><td>RA3</td><td>0.49</td></tr>
<tr><td>RA4</td><td>0.67</td></tr>
<tr><td>RA5</td><td>0.83</td></tr>
<tr><td>RA6</td><td>0.65</td></tr>
</table>

* As conceptualized by Ragunathan, Ragunathan and Tu (1999), the "Future Portfolio" construct actually has three sub-factors, i.e., factor 1–future projects for product and service differentiation; factor 2 – future projects for operational and decision support; factor 3 – future projects for systems enhancement. For the purpose of LISREL structural modeling in this paper, we took the mean value of all 9 items of the three sub-factors to represent the "Future Portfolio" variable.

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Index