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Global, Social, and Organizational Implications of Emerging Information Resources Management

Concepts and Applications

Mehdi Khosrow-Pour

Global, Social, and Organizational Implications of Emerging Information Resources Management:
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Mehdi Khosrow-Pour
Information Resources Management Association, USA

Information Science REFERENCE

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Hershey · New York

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Typesetter: Mike Killian, Carole Coulson, Sean Woznicki
Cover Design: Lisa Tosheff
Printed at: Yurchak Printing Inc.

Published in the United States of America by
Information Science Reference (an imprint of IGI Global)
701 E. Chocolate Avenue
Hershey PA 17033
Tel: 717-533-8845
Fax: 717-533-8661
E-mail: cust@igi-global.com
Web site: http://www.igi-global.com/reference

Library of Congress Cataloging-in-Publication Data

Global, social, and organizational implications of emerging information resources management : concepts and applications / Mehdi Khosrow-Pour, editor.
p. cm.

Includes bibliographical references and index.

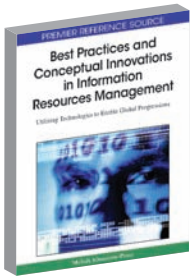
ISBN 978-1-60566-962-5 (hbk.) -- ISBN 978-1-60566-963-2 (ebook) 1. Information technology--Management. 2. Information resources management. 3. Offshore outsourcing. I. Khosrowpour, Mehdi, 1951-
HD30.2.G577 2010
658.4'038--dc22
2009042523

British Cataloguing in Publication Data
A Cataloguing in Publication record for this book is available from the British Library.

Advances in Information Resources Management (AIRM)

ISBN: 1537-3367

Editor-in-Chief: Mehdi Khosrow-Pour, D.B.A.



Best Practices and Coceptual Innovations in Information Resources Management: Utilizing Technologies to Enable Global Progressions

Mehdi Khosrow-Pour, Information Resources Management Association, USA

Information Science Reference • copyright 2009 • 370 pp • H/C (ISBN: 978-1-60566-128-5) •

Continuous technological innovation amidst the increasing complexity of organizational structures and operations has created the need to achieve a new level of skillful performance and innovative procedures within the information resources management sector. Best Practices and Conceptual Innovations in Information Resources Management: Utilizing Technologies to Enable Global Progressions provides authoritative insight into emerging developments in information resources management and how these technologies are shaping the way the world does business, creates policies, and advances organizational practices. With chapters delving into pertinent aspects of such disciplines as knowledge management, open source software, systems engineering, project management, and IT governance, this book offers audiences solutions for improved organizational functioning.

Innovative Technologies for Information Management

Mehdi Khosrow-Pour, Information Resources Management Association, USA

Information Science Reference • copyright 2009 • 370 pp • H/C (ISBN: 978-1-59904-570-2)

As information resource management becomes increasingly dependent on emerging technologies to combat its challenges and decipher its effective strategies, the demand builds for a critical mass of research in this area. Innovative Technologies for Information Resource Management brings together compelling content related to the continually emerging technologies in areas of information systems such as Web services, electronic commerce, distance learning, healthcare, business process management, and software development. Focusing on the implications innovative technologies have on the managerial and organizational aspects of information resource management, this book provides academcians and practitioners with a requisite and enlightening reference source.

Emerging Information Resources Management Technologies

Mehdi Khosrow-Pour, Information Resources Management Association, USA

IGI Publishing • copyright 2007 • 300 pp • H/C (ISBN: 1-59904-286-X)

In the time of constant technological and managerial advancement, firms of the 21st century are faced with an ongoing quest for implementing more effective strategies and methodologies to remain at the apex of the information resources management industry. Researchers and pioneers of academia incessantly delve into potential solutions to increase efficacy within technological and information resources management, as well as identify the emerging technologies and trends. Emerging Information Resources Management and Technologies supplies the industry leaders, practicing managers, researchers, experts, and educators with the most current findings on undertaking the operation of the latest information technology reforms, developments, and changes. Emerging Information Resources Management and Technologies presents the issues facing modern organizations and provides the most recent strategies in overcoming the obstacles of the ever-evolving information management and utilization industry.

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comprised of three closely coordinated components seamlessly interwoven together: healthcare tasks performed by humans on-site; healthcare tasks performed by humans off-site, including tasks performed in other countries; and healthcare tasks performed by computers without direct human involvement. Finally, this chapter deals with intellectual property and legal aspects related to the three-pronged healthcare services paradigm.

This chapter covers four issues. First, it examines evolving international conventions to determine whether countries, especially developed countries, can take any steps to inhibit offshoring with the objective of protecting jobs in their respective countries. Second, it looks at statistics from independent sources to see if outsourcing exceeds insourcing, or vice versa, in the case of the U.S. Third, it looks at trends in outsourcing in the legal arena. Fourth, it looks at the intellectual property aspects of outsourcing and presents a long-term vision on how this ticklish issue is likely to be addressed in the long-term.

In an outsourced database service model, query assurance takes an important role among well-known security issues. To the best of the author's knowledge, however, none of the existing research work has dealt with ensuring the query assurance for outsourced tree-indexed data. To address this issue, the system must prove authenticity and data integrity, completeness, and freshness guarantees for the result set. These objectives imply that data in the result set is originated from the actual data owner and has not been tampered with; the server did not omit any tuples matching the query conditions; and the result set was generated with respect to the most recent snapshot of the database. In this chapter, the author proposes a vanguard solution to provide query assurance for outsourced tree-indexed data on untrusted servers with high query assurance and at reasonable costs. Experimental results with real datasets confirm the efficiency of the approach and theoretical analyses.

In the age in which many traditional IS functions will be taken over by offshore vendors or otherwise outsourced, attention needs to be paid to those functions that will increase in importance and/or need to be developed by IS departments if they are to be effective in this new environment. This chapter suggests a framework that may be judgmentally applied to IS activities in order to determine if they should

be considered for offshoring/outsourcing. The results of applying the framework will be unique to each firm that uses it. However, in using that approach in more than 25 firms, the author has found that most firms will wish to retain a number of functions in-house. Fourteen such activities are discussed in three broad categories: "activities related to external relations," "activities related to the development, customization, and implementation of systems" and "business and IS strategic activities."

This chapter examines the role of business related firm level variables in determining the offshoring intensity of firms. The four business related variables that are analyzed in this study are: business size, business cost, business financial leverage, and business performance. The results indicate a significant relationship between business size and offshoring intensity, and also between business financial leverage and offshoring intensity. Based on the results, the authors analyze similarities and differences between traditional onshore IS outsourcing and IS offshoring. Implications and contributions arising out of this study are also discussed.

Inspired by round-the-clock manufacturing, the 24-Hour Knowledge Factory endeavors to transform the production of software and other intangibles into a process of continuous development. While the concept of offshore software development is well established, few enterprises are currently able to develop the same code artifacts around the clock. The authors discuss the benefits of applying the 24-Hour Knowledge Factory to software development. The authors also present a representative scenario highlighting the problems of asynchronous communication in current offshore software development practices. Further, this chapter introduces the notion of composite persona as a potential collaboration model within the 24-Hour Knowledge Factory and explain its ability to mitigate problems arising from communicating across cultures, languages, and time zones. Finally, the authors present a suite of new collaboration tools and techniques that are being developed specifically for use by composite personae in the 24-Hour Knowledge Factory.

In an IT-intensive global business process sourcing (global BPS) project, the structure chosen to control knowledge transfer is critical. The objective of this study is to explore the effective control structure for knowledge transfer in IT-intensive global BPS project. The research methods used in this study are a case study and survey. First, a generic framework on the control structure for knowledge transfer is derived from extant literature. This framework is applied to a case analysis of a service provider in Mauritius. As a result of the case analysis, a model for control structure facilitating knowledge transfer in global BPS is derived. The model includes a social control mechanism, communication mechanism, project control mechanism as independent variables, and governance mechanism as a moderator variable. The degree of knowledge transfer and success of global BPS are used as dependent variables. The propositions describing the relationships between the variables are formulated. A total of 19 survey items were generated for these variables. As results of the survey, the model is revised and a set of more refined propositions are generated in the conclusion. Both service providers and clients can benefit from this study by focusing on control mechanisms that affect the knowledge transfer and BPS success.

The use of outsourcing is expanding rapidly. This study empirically tests a model of application development outsourcing acceptance based on the technology acceptance model (TAM). TAM suggested perceived usefulness and ease of use mediate the effects of other variables on users' attitudes towards a technology. The model tested in this study suggests perceived usefulness and ease of use of outsourcing mediate the effects of the external environment, prior outsourcing relationships, and risks on decision-makers' attitude toward application development outsourcing. One hundred and sixty respondents to a survey sent to 3000 IT decision makers provided data to confirm the applicability of TAM and the influences of these external variables. Support for applying TAM in this alternative context was found. Three sub-dimensions of risk, project management, relationship, and employee risk emerged. Project management and employee risks along with prior relationships were found to significantly influence decision maker perceptions about application development outsourcing.

The present study attempts to investigate the applicability of the TAM model in the Arab context and to extend TAM with three moderating/interacting human factors. Using a survey sample collected from 722 knowledge workers using desktop computer applications on a voluntary basis in Saudi Arabia, this study sought empirical support for testing the basic structure of TAM. Toward that, the study was successful as the structure of TAM holds well in the Saudi settings. This study also empirically examined an extended TAM by incorporating gender, age and educational level as moderators of the model's core relationships. The author's findings emphasize that most of the key relationships in the model are moder-

ated. Specifically, age moderates all the influences of computers usefulness and ease of use on attitudes and intention to use. However, gender and educational level only moderate the influence of ease of use on attitudes. Implications for management and practice of these findings are discussed.

Over the past few years, the marketplace and the trade press have recognized the value derived from using enterprise resource planning (ERP) systems for decision making support. However, research studies have tended to concentrate primarily on the use of ERP systems on their transactional and record-keeping aspects. This study used the technology acceptance model (TAM) to evaluate the impact of a set of individual differences (demographics, computer self efficacy, and knowledge of the system), system characteristics (relevance, terminology and screen design), and perceived benefits of the system, on the intentions to use ERP systems for decision support. A field study was used to collect data from managers working in Bahraini enterprises that use ERP systems.

While the value of the Capability Maturity Model (CMM), ISO 9000, and Total Quality Management (TQM) concepts in managing software quality has been widely acknowledged, shortcomings of these approaches have also been recognized. The current research synthesizes existing literature bases in CMM, ISO 9000, TQM, among others, to identify six critical factors of Software Quality Management (SQM) and then develops an instrument that can be used to measure critical factors of SQM. Validity and reliability are established by reviewing existing literature, testing a preliminary version of the instrument among a group of researchers and industry experts, and empirically testing a revised version of the instrument among a group of IS professionals. The authors conclude by addressing quality management research issues in the emerging open source software (OSS) paradigm.

Managers are increasingly confronting the question of how to convey electronic information to e-commerce users in a manner that permits individuals to resolve information search related problems more easily. Information service quality and the associated performance outcomes are challenging to manage

during Web-based interactions, primarily because such settings involve several features (i.e., less tangible contact, more uncertainty, differing feedback loops between business and consumers) not found in more traditional exchanges. To capture a broader view of the quality of information offerings in ecommerce settings, the model tested in this study compares the DeLone and McLean (2003) framework, one that includes use as an outcome measure, with a model suggested by Landrum and Prybutok (2004), one that features usefulness as its outcome measure. A random sample of Army Corp of Engineers library customers was performed at two library sites with the Corps. Theoretical and applied implications are developed and discussed.

Today, a majority of information systems are being developed for Web environments. It is critical to understand the unique characteristics of Web-based information systems. The main objective of this study is to identify the relative importance of factors related to the development of Web-based information systems. To accomplish this, critical success factors (CSFs) for the development of Web-based applications were identified from the literature, and organized into two main dimensions and sub-dimensions. The relative importance of the dimensions was assessed through an analytical hierarchy process (AHP) method. Data were obtained in Korea from 33 experienced IT professionals representing six organizations from three different industry sectors. Respondents provided information about the relative importance of dimensions in pair-wise comparisons. As a result of the AHP analysis, information properties were found to be more important than risk control. Within information properties dimension, integrity of information was found to be the most important sub-dimension. The authors' analysis also revealed that there is an industry effect on the relative importance of the dimensions. The results appeared to be reasonable for each industry sector given its business characteristics and nature of customer interactions, contingent on industry sectors. Based on these results, a series of research questions are suggested for future studies.

Consumer-opinion Web sites provide people with unparalleled opportunities to articulate their opinions on products and services, read those of others, or interact with other consumers. The success of such Web sites is limited by three challenges: the quality of contributions, users' motivation to participate, and readers' trust in the writer's competence. Drawing on the concept of media richness, this chapter investigates how such Web sites could provide richer and more useful exchanges to both consumers and companies. The results suggest that consumer-opinion Web sites can provide richer exchanges when they separate the tasks of information exchange and social interaction and support them with appropriate levels of richness.

Little is known about the relationship between of the level of fulfillment of the IT professional's psychological contract and their innovative work and organizational citizenship behaviors. Using psychological contract and social information processing theories, this study proposes to answer the research question: What is the relationship between the level of fulfillment of the IT professionals' psychological contract and their organizational citizenship and innovative work behaviors? Survey data were collected from 209 IT professionals using group-administered paper and on-line surveys. Results show positive relationships with the level of fulfillment of the IT professional's psychological contract and their innovative work behavior, as well as four of their organizational citizenship behaviors, specifically loyalty, advocacy participation, obedience, and functional participation. Extending the body of knowledge, the dimensional approach of the psychological contract was used resulting in the scope, focus, and tangibility dimensions being the most significant predictors of the organizational behaviors.

This chapter is an attempt to investigate the role of negotiation support systems (NSS) in supporting inter-team negotiations, which have become commonplace for today's business negotiations. Inter-team negotiations differ from simple dyadic negotiations, and are associated with enormous complexity introduced by the negotiating team dynamics. When there are three or more members in a negotiating team, coalition formation by team members stands out as an intriguing phenomenon, of which cultural diversity is a primary antecedent. NSS through altering coalition formation dynamics have important impacts on various negotiation outcomes. An experiment was conducted to test the authors' research model and hypotheses. A content analysis was undertaken to measure the extent of coalition formation. Besides the quantitative approach, a qualitative analysis was also conducted to further enhance the authors' exploratory efforts in examining the phenomenon. The results provide initial evidence of the usefulness of NSS in supporting inter-team negotiations, and have both theoretical and practical implications.

Preface

In today's global society, it has become increasingly important to address the current challenges, obstacles, and solutions encountered by researchers in the field of information resources management. This collection, entitled *Global, Social, and Organizational Implications of Emerging Information Resources Management: Concepts and Applications*, highlights recent trends and advancements as they impact all facets of information resources management in an ever-changing society. Specific submissions focus on the role outsourcing has played in modern business, the development of Web information systems, and social issues such as explorations of age-based salary differences and workplace stress.

Chapter 1, "A Paradigmatic and Methodological Review of Research in Outsourcing" by Vanita Yadav and Rajen K. Gupta addresses the need to do a comprehensive assessment and synthesis of research activities to date and examines the academic literature on information systems outsourcing and business process outsourcing using a paradigmatic and methodological lens. The objective of this chapter is fourfold. Firstly, it examines the status of outsourcing research from 1995 to 2005 in eight leading academic journals, to compare the current research trends with past research directions in terms of methodologies applied. Secondly, it analyzes the research paradigms adopted in these research papers using the Operations Research Paradigm framework. Thirdly, it compares and contrasts the outsourcing research work published in three leading European journals with the work published in three leading American journals. Finally, it uncovers the implications of this study and the directions for future research.

Chapter 2, "Outsourcing in the Healthcare Industry: Information Technology, Intellectual Property, and Allied Aspects" by Amar Gupta, Raj K. Goyal, Keith A. Joiner, and Sanjay Saini discusses the four major ways in which the healthcare industry is being impacted by information technology: first, a broad spectrum of tasks that were previously done manually can now be performed by computers; second, some tasks can be outsourced to other countries using inexpensive communications technology; third, longitudinal and societal healthcare data can now be analyzed in acceptable periods of time; and fourth, the best medical expertise can sometimes be made available without the need to transport the patient to the doctor or vice versa. The healthcare industry will increasingly use a portfolio approach comprised of three closely coordinated components seamlessly interwoven together: healthcare tasks performed by humans on-site; healthcare tasks performed by humans off-site, including tasks performed in other countries; and healthcare tasks performed by computers without direct human involvement. Finally, this chapter deals with intellectual property and legal aspects related to the three-pronged healthcare services paradigm.

Chapter 3, "Evolving Relationship between Law, Offshoring of Professional Services, Intellectual Property, and International Organizations" by Amar Gupta, David A. Gantz, Devin Sreecharana, and Jeremy Kreyling covers four issues. First, it examines evolving international conventions to determine

whether countries, especially developed countries, can take any steps to inhibit offshoring with the objective of protecting jobs in their respective countries. Second, it looks at statistics from independent sources to see if outsourcing exceeds insourcing, or vice versa, in the case of the U.S. Third, it looks at trends in outsourcing in the legal arena. Fourth, it looks at the intellectual property aspects of outsourcing and presents a long-term vision on how this ticklish issue is likely to be addressed in the long-term.

Chapter 4, "Ensuring Correctness, Completeness, and Freshness for Outsourced Tree-Indexed Data" by Tran Khanh Dang, proposes a vanguard solution to provide query assurance for outsourced tree-indexed data on untrusted servers with high query assurance and at reasonable costs. Experimental results with real datasets confirm the efficiency of the approach and theoretical analyses.

Chapter 5, "The Post-Offshoring IS Organizations" by William R. King suggests a framework that may be judgmentally applied to IS activities in order to determine if they should be considered for offshoring/outsourcing. The results of applying the framework will be unique to each firm that uses it. However, in using that approach in more than 25 firms, the author has found that most firms will wish to retain a number of functions in-house. Fourteen such activities are discussed in three broad categories: "activities related to external relations," "activities related to the development, customization, and implementation of systems" and "business and IS strategic activities."

Chapter 6, "Is Information Systems (IS) Offshoring an Extension of IS Outsourcing?: Concept, Definition and Determinants" by Shirish C. Srivastava, Thompson S. H. Teo, and Partha S. Mohapatra, examines the role of business related firm level variables in determining the offshoring intensity of firms. The four business related variables that are analyzed in this study are: business size, business cost, business financial leverage, and business performance. The results indicate a significant relationship between business size and offshoring intensity, and also between business financial leverage and offshoring intensity. Based on the results, the authors analyze similarities and differences between traditional onshore IS outsourcing and IS offshoring. Implications and contributions arising out of this study are also discussed.

Chapter 7, "Hybrid Offshoring: Composite Personae and Evolving Collaboration Technologies" by Nathan Denny, Shivram Mani, Ravi Sheshu Nadella, Manish Swaminathan, and Jamie Samdal, discusses the benefits of applying the 24-Hour Knowledge Factory to software development. The authors also present a representative scenario highlighting the problems of asynchronous communication in current offshore software development practices. Further, this chapter introduces the notion of composite persona as a potential collaboration model within the 24-Hour Knowledge Factory and explain its ability to mitigate problems arising from communicating across cultures, languages, and time zones. Finally, the authors present a suite of new collaboration tools and techniques that are being developed specifically for use by composite personae in the 24-Hour Knowledge Factory.

Chapter 8, "Exploratory Study on Effective Control Structure in Global Business Process Sourcing" by Gyeung-min Kim and Saem-Yi Kim, explores the effective control structure for knowledge transfer in IT-intensive global BPS project. The research methods used in this study are a case study and survey. First, a generic framework on the control structure for knowledge transfer is derived from extant literature. This framework is applied to a case analysis of a service provider in Mauritius. As a result of the case analysis, a model for control structure facilitating knowledge transfer in global BPS is derived. The model includes a social control mechanism, communication mechanism, project control mechanism as independent variables, and governance mechanism as a moderator variable. The degree of knowledge transfer and success of global BPS are used as dependent variables. The propositions describing the relationships between the variables are formulated. A total of 19 survey items were generated for these

variables. As results of the survey, the model is revised and a set of more refined propositions are generated in the conclusion. Both service providers and clients can benefit from this study by focusing on control mechanisms that affect the knowledge transfer and BPS success.

Chapter 9, "An Outsourcing Acceptance Model: An Application of TAM to Application Development Outsourcing Decisions" by John "Skip" Benamati and T.M. Rajkumar empirically tests a model of application development outsourcing acceptance based on the technology acceptance model (TAM). TAM suggested perceived usefulness and ease of use mediate the effects of other variables on users' attitudes towards a technology. The model tested in this study suggests perceived usefulness and ease of use of outsourcing mediate the effects of the external environment, prior outsourcing relationships, and risks on decision-makers' attitude toward application development outsourcing. One hundred and sixty respondents to a survey sent to 3000 IT decision makers provided data to confirm the applicability of TAM and the influences of these external variables. Support for applying TAM in this alternative context was found. Three sub-dimensions of risk, project management, relationship, and employee risk emerged. Project management and employee risks along with prior relationships were found to significantly influence decision maker perceptions about application development outsourcing.

Chapter 10, "Testing for the Applicability of the TAM Model in the Arabic Context: Exploring an Extended TAM with Three Moderating Factors" by Said S. Al-Gahtani attempts to investigate the applicability of the TAM model in the Arab context and to extend TAM with three moderating/interacting human factors. Using a survey sample collected from 722 knowledge workers using desktop computer applications on a voluntary basis in Saudi Arabia, this study sought empirical support for testing the basic structure of TAM. Toward that, the study was successful as the structure of TAM holds well in the Saudi settings. This study also empirically examined an extended TAM by incorporating gender, age and educational level as moderators of the model's core relationships. The author's findings emphasize that most of the key relationships in the model are moderated. Specifically, age moderates all the influences of computers usefulness and ease of use on attitudes and intention to use. However, gender and educational level only moderate the influence of ease of use on attitudes. Implications for management and practice of these findings are discussed.

Chapter 11, "Factors Influencing the Use of Decision Support Tools of Enterprise Resource Planning Systems" by Emad M. Kamhawi uses the technology acceptance model (TAM) to evaluate the impact of a set of individual differences (demographics, computer self efficacy, and knowledge of the system), system characteristics (relevance, terminology and screen design), and perceived benefits of the system, on the intentions to use ERP systems for decision support. A field study was used to collect data from managers working in Bahraini enterprises that use ERP systems.

Chapter 12, "Software Quality Management: Measurement and Research Directions" by Padmal Vitharana and Mark A. Mone synthesizes existing literature bases in CMM, ISO 9000, TQM, among others, to identify six critical factors of Software Quality Management (SQM) and then develops an instrument that can be used to measure critical factors of SQM. Validity and reliability are established by reviewing existing literature, testing a preliminary version of the instrument among a group of researchers and industry experts, and empirically testing a revised version of the instrument among a group of IS professionals. The authors conclude by addressing quality management research issues in the emerging open source software (OSS) paradigm.

Chapter 13, "Is "Usefulness" or "Use" the Superior Metric When Assessing Web-Based Information System Success?" by Hollis T. Landrum, Victor R. Prybutok, David Strutton, and Xiaoni Zhang confronts the question of how to convey electronic information to e-commerce users in a manner that

permits individuals to resolve information search related problems more easily. Information service quality and the associated performance outcomes are challenging to manage during Web-based interactions, primarily because such settings involve several features (i.e., less tangible contact, more uncertainty, differing feedback loops between business and consumers) not found in more traditional exchanges. To capture a broader view of the quality of information offerings in ecommerce settings, the model tested in this study compares the DeLone and McLean (2003) framework, one that includes use as an outcome measure, with a model suggested by Landrum and Prybutok (2004), one that features usefulness as its outcome measure. A random sample of Army Corp of Engineers library customers was performed at two library sites with the Corps. Theoretical and applied implications are developed and discussed.

Chapter 14, "Identification of Critical Success Factors (CSF) and their Relative Importance for Web-Based Information Systems Development" by Kyootai Lee, Kailash Joshi, and Mueun Bae identifies the relative importance of factors related to the development of Web-based information systems. To accomplish this, critical success factors (CSFs) for the development of Web-based applications were identified from the literature, and organized into two main dimensions and sub-dimensions. The relative importance of the dimensions was assessed through an analytical hierarchy process (AHP) method. Data were obtained in Korea from 33 experienced IT professionals representing six organizations from three different industry sectors. Respondents provided information about the relative importance of dimensions in pair-wise comparisons. As a result of the AHP analysis, information properties were found to be more important than risk control. Within information properties dimension, integrity of information was found to be the most important sub-dimension. The authors' analysis also revealed that there is an industry effect on the relative importance of the dimensions. The results appeared to be reasonable for each industry sector given its business characteristics and nature of customer interactions, contingent on industry sectors. Based on these results, a series of research questions are suggested for future studies.

Chapter 15, "Media Richness in Online Consumer Interactions: An Exploratory Study of Consumer-Opinion Web Sites" by Irene Pollach investigates how consumer-opinion Web sites could provide richer and more useful exchanges to both consumers and companies. The results suggest that consumer-opinion Web sites can provide richer exchanges when they separate the tasks of information exchange and social interaction and support them with appropriate levels of richness.

Chapter 16, "Revisiting the Impact of Information Technology Investments on Productivity: An Empirical Investigation Using Multivariate Adaptive Regression Splines (MARS)" by Myung Ko, Jan Guynes Clark, and Daijin Ko revisits the relationship between IT and productivity, and investigates the impact on information technology (IT) investments. Using the MARS techniques, the authors show that although IT Stock is the greatest predictor variable for productivity (Value Added), it is only significant as an interaction variable, combined with Non-IT Capital, Non-IT Labor, Industry, or Size.

Chapter 17, "Building the IT Workforce of the Future: The Demand for More Complex, Abstract, and Strategic Knowledge" by Deborah J. Armstrong, H. James Nelson, Kay M. Nelson, and V.K. Narayanan uses revealed causal mapping techniques to examine the change in mindset that occurs across the procedural to OO development transition, and lays the foundation for future studies of the OO/ pattern cognitive transition. The results indicate that there is not only increasing complexity in the cognitive maps of the OO developers, but also that there is a need for the developer to shift from routine, assembly line coding to more abstract thought processes.

Chapter 18, "Perception Gaps about Skills Requirement for Entry-Level IS Professionals between Recruiters and Students: An Exploratory Study" by Sooun Lee and Xiang Fang explains that dramatic changes in the U.S. economic situations and offshore outsourcing trends in the IT (Information Tech-

nology) industry have affected the IS (Information Systems) job market and recruiters with regard to IS knowledge/skills that their new hires should possess. Keeping pace with these changes presents a challenge for IS recruiters and students. There is an urgent need for a study that investigates the perception gaps between IS recruiters and students about the knowledge/skill sets required for a new entry-level IS hire. This study reports the findings from a survey of IS recruiters and IS students in the U.S., detailing the differences of their understanding about the knowledge/skills requirement.

Chapter 19, "The Relationship between the Fulfillment of the IT Professional's Psychological Contract and their Organizational Citizenship and Innovative Work Behaviors" by Sandra K. Newton, Linda I. Nowak, and J. Ellis Blanton proposes to answer the research question: What is the relationship between the level of fulfillment of the IT professionals' psychological contract and their organizational citizenship and innovative work behaviors? Survey data were collected from 209 IT professionals using group-administered paper and on-line surveys. Results show positive relationships with the level of fulfillment of the IT professional's psychological contract and their innovative work behavior, as well as four of their organizational citizenship behaviors, specifically loyalty, advocacy participation, obedience, and functional participation. Extending the body of knowledge, the dimensional approach of the psychological contract was used resulting in the scope, focus, and tangibility dimensions being the most significant predictors of the organizational behaviors.

Chapter 20, "Inter-Team Negotiation Support, Coalition Formation, and Negotiation Outcomes: An Empirical Study" by Xiaojia Guo, John Lim, and Fei Wang investigates the role of negotiation support systems (NSS) in supporting inter-team negotiations, which have become commonplace for today's business negotiations. Inter-team negotiations differ from simple dyadic negotiations, and are associated with enormous complexity introduced by the negotiating team dynamics. When there are three or more members in a negotiating team, coalition formation by team members stands out as an intriguing phenomenon, of which cultural diversity is a primary antecedent. NSS through altering coalition formation dynamics have important impacts on various negotiation outcomes. An experiment was conducted to test the authors' research model and hypotheses. A content analysis was undertaken to measure the extent of coalition formation. Besides the quantitative approach, a qualitative analysis was also conducted to further enhance the authors' exploratory efforts in examining the phenomenon. The results provide initial evidence of the usefulness of NSS in supporting inter-team negotiations, and have both theoretical and practical implications.

Chapter 21, "Impact of Age on Information Technology Salaries" by Jing Quan, Ronald Dattero, and Stuart D. Galup examines the treatment of information technology professionals using the Human Capital Model. The model results suggest that age treatment discrimination exists but varies across industries and job functions. The authors present explorative theories to explain why such variations exist and draw managerial implications based on the results.

Chapter 22, "An Empirical Investigation of Stress Factors in Information Technology Professionals" by Vijay V. Raghavan, Toru Sakaguchi, and Robert C. Mahaney explores whether organizations can employ job design strategies to relieve organizational stress for information technology (IT) professionals. The effect of flexible work schedule, employee support and training, and telecommuting as potential coping resources to relieve stress were studied. Perceived workload, role ambiguity, work facilitation, and decision latitude were drawn from previous studies as potential stressors of IT professionals. Perceived stress was measured by two commonly used measures: work exhaustion and depressed mood. The results suggest that removing role ambiguity and improving work-facilitation ease work-related stress. Allowing employees to have flexible work schedules was also found to ease their perceptions of

workload. Employee support and training strategies were found to influence decision latitude and role ambiguity. Telecommuting did not have any effect on the stressors. Results also indicate that the association between work exhaustion and depressed mood was stronger for males than females.

Chapter 23, "Information Technology Portfolio Management: Literature Review, Framework, and Research Issues" by Ram Kumar, Haya Ajjan, and Yuan Niu compares IT portfolio management (ITPM) with other types of portfolio management, and develops an improved understanding of IT assets and their characteristics. It presents a process-oriented framework for identifying critical ITPM decision stages. The proposed framework can be used by managers as well as researchers.

Global, Social, and Organizational Implications of Emerging Information Resources Management: Concepts and Applications contains current findings relating to trends and developments in information resources management in the face of constant technological innovation and adaptation. The ways in which technology has shaped our economic and social fabrics is evident in these selections, which remark on issues, trends, and advancements in the modern-day global business.

Chapter 1
A Paradigmatic and Methodological Review of Research in Outsourcing

Vanita Yadav
Management Development Institute, India

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ABSTRACT

Due to the growing academic and practitioner interest in the field of outsourcing, there is a need to do a comprehensive assessment and synthesis of research activities to date. This article addresses this need and examines the academic literature on information systems outsourcing and business process outsourcing using a paradigmatic and methodological lens. The objective of this article is fourfold. Firstly, it examines the status of outsourcing research from 1995 to 2005 in eight leading academic journals, to compare the current research trends with past research directions in terms of methodologies applied. Secondly, it analyzes the research paradigms adopted in these research papers using the Operations Research Paradigm framework. Thirdly, it compares and contrasts the outsourcing research work published in three leading European journals with the work published in three leading American journals. Finally, it uncovers the implications of this study and the directions for future research.

INTRODUCTION

Eastman Kodak's decision to outsource its information systems (IS) function in 1989 to IBM, DEC, and Businessland formally launched the phenomenon of outsourcing in the corporate world which aroused interest worldwide. *Outsourcing* is defined as the procurement of products and services from sources that are external to the organization (Lankford & Parsa, 1999). The e-commerce revolution has forced the transformation of traditional IS outsourcing structures

into new outsourcing service configurations, like *Internet service outsourcing, application service outsourcing,* and *business process (BP) outsourcing* (Watjatrakul, 2005).

Businesses today are growing in complexity and the world is moving towards globalization. As a result the forces of outsourcing have become a present-day reality and are poised for phenomenal growth in the future. The importance of outsourcing in industry has led to extensive research in this area. Most of the research done in outsourcing is in the field of IS outsourcing. In the last few years, there has been a rise in another more process-centric approach to outsourcing—*business process outsourcing,* in which the outsourcing vendor offers to take responsibility for an entire client process (Harmon, 2003). Due to the growing academic and practitioner interest in the field of outsourcing, there is a need to do a comprehensive assessment of research activities to date. This article aims to address this need of exploring and synthesizing the academic literature on outsourcing.

Although Dibbern, Goles, Hirschheim, Rudy, and Jayatilaka (2004) and Gonzalez, Gasco, and Llopis (2006) have carried out a survey and analysis of literature in the field of IS outsourcing, the goal of this research is to extend existing insights. The focus of Gonzalez et al.'s (2006) IS outsourcing review was to identify the main topics of IS outsourcing, the methodologies most often applied, and the authors and countries that have contributed most to the area of IS outsourcing. The focus of Dibbern et al.'s (2004) IS outsourcing review was on research objectives, methods used, and theoretical foundations to view outsourcing as an organizational decision process using Simon's model of decision making. In contrast, our study covers IS as well as BP outsourcing research, and carries out a methodological and paradigmatic examination of literature. Hence this study makes a contribution to the philosophical and methodological foundations of research in outsourcing. Additionally, it also presents a comparative analysis of the outsourcing research trends in leading American and European journals.

The objective of this article is fourfold. Firstly, it examines the status of outsourcing research in from 1995 to 2005 in eight leading academic journals, to compare the current research trends with past research directions in terms of methodologies applied. Secondly, it analyzes the research paradigms adopted in these research papers using the Operations Research Paradigm framework of Meredith, Raturi, Amoako-Gyampah, and Kaplan (1989). Thirdly, it compares and contrasts the outsourcing research work published in three leading European journals with the work published in three leading American journals. Finally, it uncovers the implications of this study and directions for future research.

The article is organized as follows. In the next section, the review of existing research literature on IS and BP outsourcing is presented. Subsequently, the choice of methodology for collecting and analyzing data is explained, followed by discussion of the results. The article ends with implications of the study, directions of future research, and contributions.

LITERATURE REVIEW

Outsourcing

Outsourcing involves contracting with an external provider for the provision of a service which may have been provided using in-house staff (Domberger, Fernandez, & Fiebig, 2000). Outsourcing has been around for more than a decade, but it got formal recognition only after the famous Kodak deal in 1989. Since then it has generated a stir in the practitioner community. Academics, by and large, have been relatively slow to research this phenomenon (Dibbern et al., 2004). While academic research has been slow to follow the practitioner community, it is now being recognized as an important area of research.

This article focuses on the following two kinds of outsourcing:

- **Information Systems Outsourcing:** Willcocks and Kern (1998) define IS outsourcing as the handing over to a third party management of IT/IS assets, resources, and/or activities for required results. Cheon, Grover, and Teng (1995) define information technology outsourcing as the organizational decision to turnover part or all of an organization's IS functions to external service provider(s) in order for an organization to be able to achieve its goals.
- **Business Process Outsourcing:** The Accenture Institute for Strategic Change suggests that BP outsourcing goes further than technology infrastructure or even applications. The outsourcing service provider takes primary responsibility for ensuring that the process works, interfaces effectively with other company functions, and delivers the outcome intended. BP outsourcing refers to an outsourcing relationship where a third-party provider is responsible for performing the entire business function for the client organization (Dibbern et al., 2004). A number of industries are considering BP outsourcing—in particular, government, financial services, healthcare, transportation, and logistics (Millar, 1994).

Research Paradigms in IS Research

Orlikowski and Baroudu (1991) and Chen and Hirschheim (2004) indicate that positivism dominates IS research while other paradigms are relatively small in number. The following three references outline the paradigmatic analysis of IS research between 1985 and 2001:

- Orlikowski and Baroudu (1991) examined 155 articles on IS research published between 1985 and 1989 in *MIS Quarterly (MISQ), Communications of the ACM (CACM), Management Science (MS),* and *Proceedings of the International Conference on Information Systems (ICIS).* Their findings indicated that positivist paradigm overwhelmingly dominated the IS research community and little attention was paid to interpretive paradigm.
- Chen and Hirschheim (2004) analyzed 1,893 articles on IS research published between 1991 and 2001 in *MISQ, Information Systems Research* (*ISR*), *Journal of Management Information Systems (JMIS), ICIS, Information and Organization (I&O), Information Systems Journal (ISJ), Journal of Information Technology (JIT),* and *European Journal of Information Systems (EJIS).* Their analysis indicates that while there has been some paradigmatic change in the IS research community since 1990, this change has not significantly manifested itself in journal publications. In most research journals, positivism maintains its prevailing dominant position.
- Dibbern et al. (2004) examined 84 articles on IS outsourcing published between 1988 and 2000 in *I&O, CACM, EJIS, JIT, JMIS, Information and Management (I&M), ISJ, ISR, MISQ, Academy of Management Journal (AMJ), Academy of Management Review (AMR), Decision Sciences (DS), MS, Organization Science (OS), Strategic Management Journal (SMJ), Harvard Business Review (HBR), California Management Review (CMR), Sloan Management Review (SMR), ICIS,* and *Hawaii International Conference on System Sciences (HICSS).* Their results indicate that there is a balanced aggregation of research approaches in IS outsourcing on the positivism-interpretivism continuum. However, the American outlets were dominated by the positivist paradigm and the European outlets were dominated by the interpretive paradigm.

METHODOLOGY

Journal Representations

For the purpose of this research, the focus was on mainstream journals that would reflect progress in the field of IS and BP outsourcing in the last 10 years, ranging from 1995 to 2005. The rationale behind the choice of leading journals in IS and management fields has been investigated by Walsham (1995), Orlikowski and Baroudu (1991), and Chen and Hirschheim (2004). The following academic journals were examined:

- Three mainstream American IS journals: *Information Systems Research, MIS Quarterly,* and *Journal of Management Information Systems.*
- Three mainstream European IS journals: *Journal of Information Technology, European Journal of Information Systems,* and *European Management Journal.*
- Two mainstream management journals: *Management Science* and *Decision Sciences.*

Paradigmatic Representations

For paradigmatic analysis, this article uses the Operations Research Paradigm framework by Meredith et al. (1989) as shown in Figure 1. This framework has been used by researchers in the operations management area (Meredith et al., 1989; Sachan & Datta, 2005). It serves as a comprehensive analysis tool in a two-dimensional format and is in the same way applicable to the field of IS research also. Hence this research extends the body of knowledge in the IS arena by using this Operations Research Paradigm framework to analyze the research paradigms in IS and BP outsourcing literature. Here it may be useful to mention that a paradigmatic perspective goes beyond the dichotomous classifications of research methods and techniques. Such a perspective helps the research community to undertake a reflective examination of its ontological and epistemological assumptions including the underlying values held by the community.

The analysis of this article focuses on the following paradigms: axiomatic, positivist, interpretive, direct observation of object reality, people's perception of object reality, and artificial construction of object reality.

Methodological Representations

The analysis of research methodology used in the identified journal papers focuses on the following areas: empirical vs. non-empirical; quantitative vs. qualitative; cross-sectional vs. longitudinal; research designs (survey, focus group, case study, experiment, and action research); sources of data; hypothesis testing; and the data analysis techniques (descriptive analysis, regression, factor analysis, correlation, cluster analysis, conjoint analysis, path analysis, Logit model, structural equation modeling).

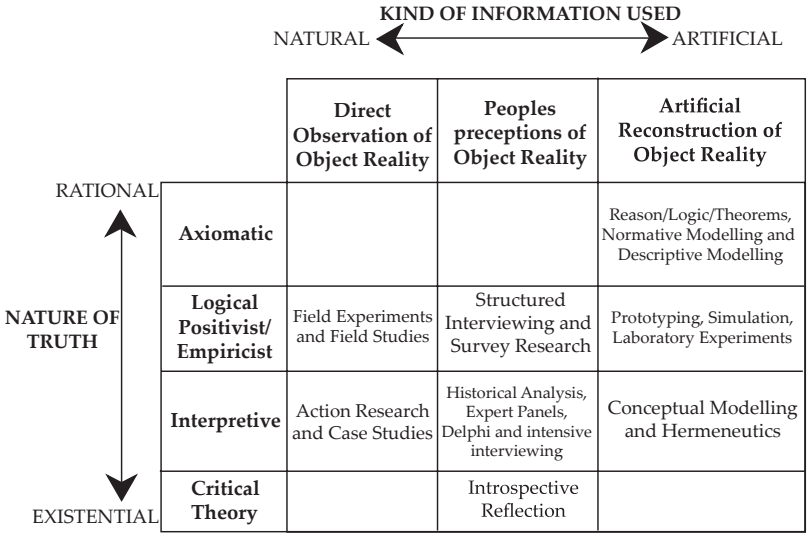
Empirical vs. Non-Empirical

The empirical studies rely on observations and data, and the non-empirical studies rely on ideas and concepts. The categorization in this research is established as empirical if the articles obtain real data or observations, which could be gathered through quantitative, qualitative, or a mixed approach, including archival data (Chen & Hirschheim, 2004).

Quantitative vs. Qualitative

The criterion for categorizing research methods as quantitative or qualitative in this article is based on whether studies use a statistical or numerical approach to collect and analyze data (Chen & Hirschheim, 2004). There is a possibility that

Figure 1. Operations research paradigm framework (adapted from Meredith et al., 1989; see Appendix 1)



	Direct Observation of Object Reality	Peoples preceptions of Object Reality	Artificial Reconstruction of Object Reality
Axiomatic			Reason/Logic/Theorems, Normative Modelling and Descriptive Modelling
Logical Positivist/ Empiricist	Field Experiments and Field Studies	Structured Interviewing and Survey Research	Prototyping, Simulation, Laboratory Experiments
Interpretive	Action Research and Case Studies	Historical Analysis, Expert Panels, Delphi and intensive interviewing	Conceptual Modelling and Hermeneutics
Critical Theory		Introspective Reflection	

research could use both quantitative and qualitative methods in different stages of the study. On such occasions, they are categorized as a *mixed research method.*

Cross-Sectional vs. Longitudinal

Chen and Hirschheim (2004) described longitudinal study as a research that evolves over an uninterrupted period of time and focuses on process. Cross-sectional study, on the other hand, is research that collects data through one snapshot at a particular point of time (Orlikowski & Baroudi, 1991).

Research Designs

Adapting the research design categorizations from Orlikowski and Baroudi (1991) and Chen and Hirschheim (2004), the following research designs were identified:

- **Survey:** Research articles involving data collection via questionnaires.
- **Focus Group:** Group discussions exploring a specific set of issues to generate data.
- **Case Study:** Research articles that are involved with a single site or a few sites over a certain period of time that involved in-depth study of a phenomenon. The case study inquiry usually relies on multiple sources of evidences (Yin, 1994).
- **Experiment:** Studies that take place within a designed, controlled environment and usually involve special treatment of different groups to contrast the precise relationships among variables (Galliers, 1991).
- **Action Research:** The researchers are an integral part of the phenomenon under study. The researchers' input often influences the outcomes of the phenomenon, and his/her role could change from researcher to subject (Galliers, 1991).
- **Others:** Articles that are practitioner oriented (systems or tools development), non-empirical pieces, or descriptive/argumentative as noted in Galliers's (1991) classification. Research with secondary data

such as public records or existing datasets is also included in this category.

Sources of Data

The sources of data involve collecting data from *primary* data sources or *secondary* data sources. The articles involving scenarios and examples have been categorized under the *others* category.

Hypothesis Testing

A hypothesis is a specific statement of prediction (Sachan & Datta, 2005). The development of science can be seen as a sequence of revisions of hypotheses. Our knowledge of reality involves sequence of trials and errors (Sachan & Datta, 2005). Under hypothesis testing, it is checked in the research paper whether the study involves explicit formulation and testing of research hypotheses.

Data Analysis Techniques

Data analysis techniques help researchers in:

- summarizing data;
- understanding the effect of variable (s) on the variable under study;
- minimizing confounding effects inherent in data, such as questionnaire data; and
- assessing alternative future scenarios.

Major techniques used for data analysis are descriptive analysis, regression factor analysis, correlation, cluster analysis, conjoint analysis, path analysis, Logit model, and structural equation modeling.

RESULTS

This article assessed the state of research in IS and BP outsourcing by examining the research

Figure 2.

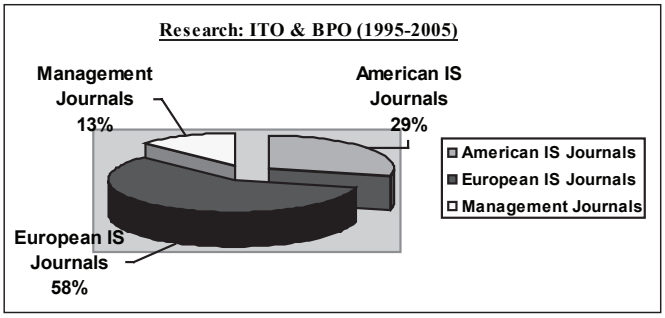
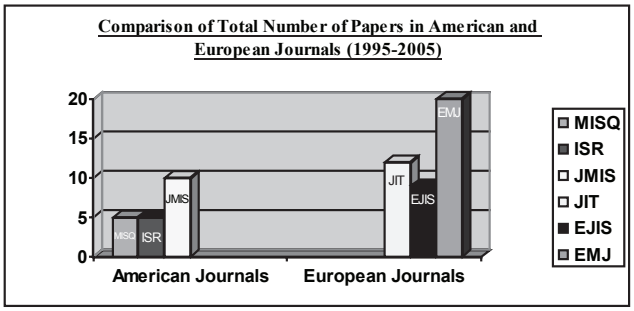


Figure 3.



paradigms and research methodologies adopted in 70 articles in eight leading academic journals between 1995 and 2005. The findings of the study reveal that on IS and BP outsourcing, between 1995 and 2005, there were 20 articles in the three American IS journals, 41 articles in the three European IS journals, and nine articles in two management science journals (see Figure 2). The European journals indicated more research in the outsourcing field (see Figure 3).

Methodological Representations

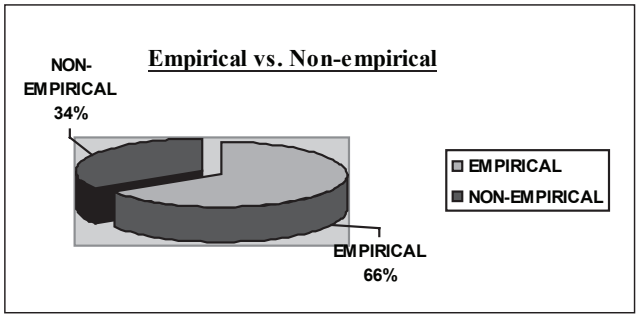
Empirical vs. Non-Empirical

Forty-three articles fell under the empirical category and 22 under the non-empirical category (see Figure 4). In American IS journals there were 10 indicating empirical approach and 10 indicating non-empirical approach. The European IS journals had 29 empirical articles and eight non-empirical articles. The management journals had four empirical articles and four non-empirical articles. American journals had an equal balance of empirical and non-empirical articles, whereas the European journals indicated applying mostly empirical approaches (see Figure 5).

Quantitative vs. Qualitative

Thirty-eight articles fell under the qualitative category and 24 under the quantitative category (see Figure 6). In American IS journals there were six indicating qualitative approach, 12 indicating quantitative approach, and two indicating mixed-method approach. The European IS journals had 30 qualitative articles, six quantitative articles, and one mixed-method article. The management journals had two qualitative articles and six quantitative articles. The American journals mainly were quantitative research focused, whereas the European journals were qualitative research focused (see Figure 7).

Figure 4.



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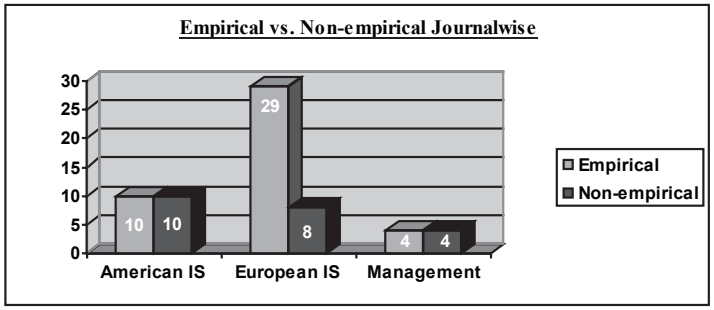

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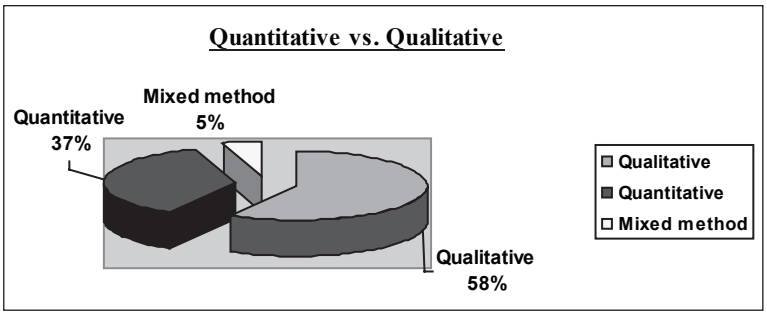

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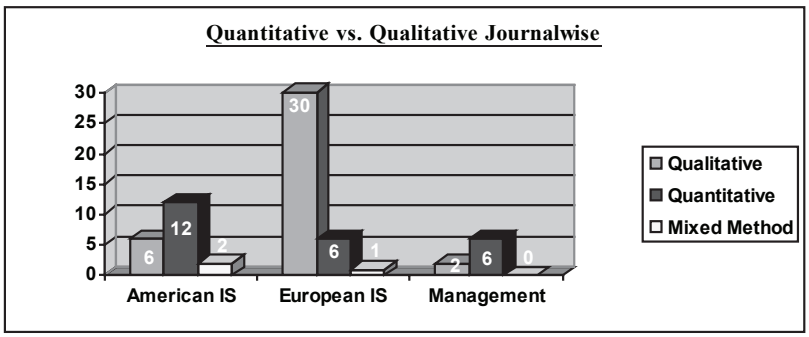
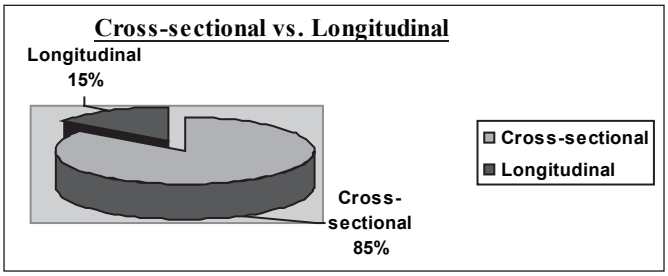


Figure 8.



Cross-Sectional vs. Longitudinal

Thirty-four articles fell under the cross-sectional category and 6 under the longitudinal category (see Figure 8). In American IS journals there were 12 indicating cross-sectional approach and one indicating longitudinal approach. The European IS journals had 21 cross-sectional articles and four longitudinal articles. The management journals had one cross-sectional article and one longitudinal article. Both the American and European journals involved mostly cross-sectional approaches (see Figure 9). The longitudinal approach was insignificant in number.

Research Designs

Fifteen articles fell under the survey research, one under focus group, 18 under case study, and 38 under the 'others' category. There were no articles

Figure 9.

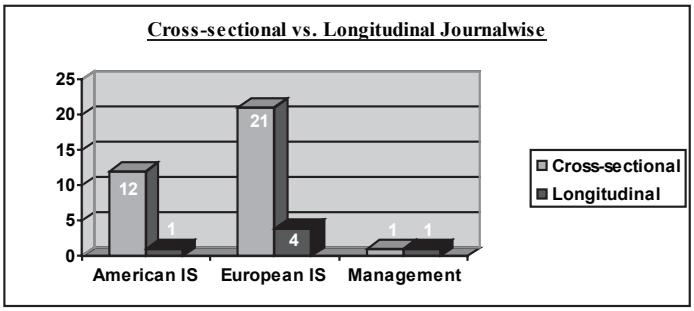


Figure 10.

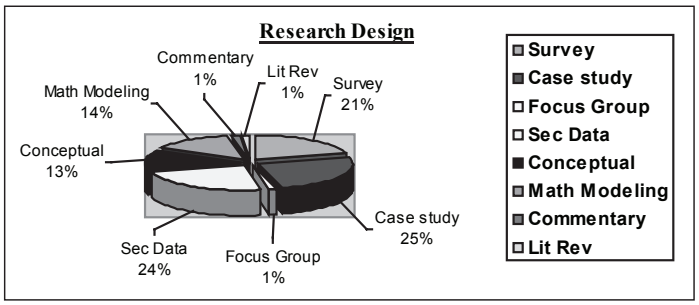
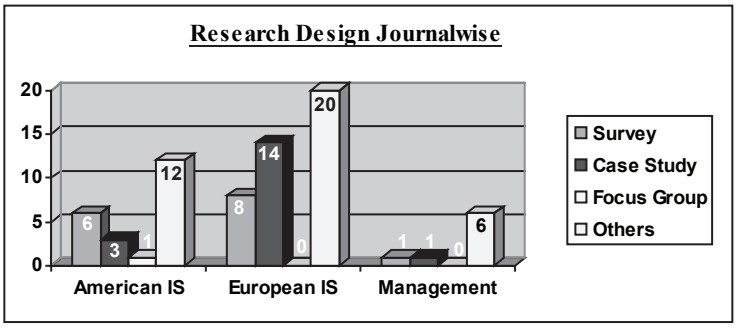


Figure 11.



under action research and experimental research. Research in the 'others' category included: one literature review paper, nine conceptual model-building papers, 10 mathematical model-building papers, one research commentary paper, and 17 papers based upon secondary data analysis. Case study research was the most predominant research design, followed by secondary data analysis and survey research (see Figures 10 and 11).

Sources of Data

There were 30 articles using primary data sources, 31 articles using secondary data sources, and 13 articles in the others category, which included examples and scenarios (see Figure 12). In American IS journals there were eight indicating primary data sources, 13 indicating secondary data sources, and seven indicating other sources. The European IS journals had 20 primary data sources articles, 14 secondary data sources articles, and

Figure 12.

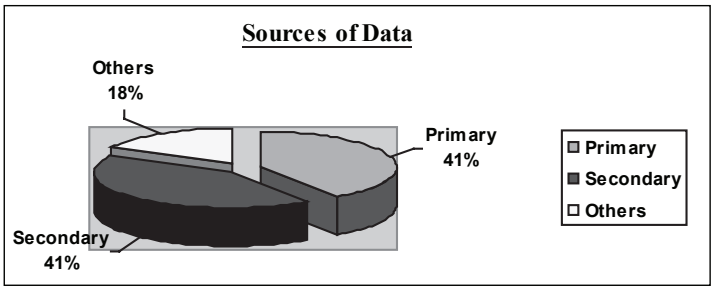


Figure 13.

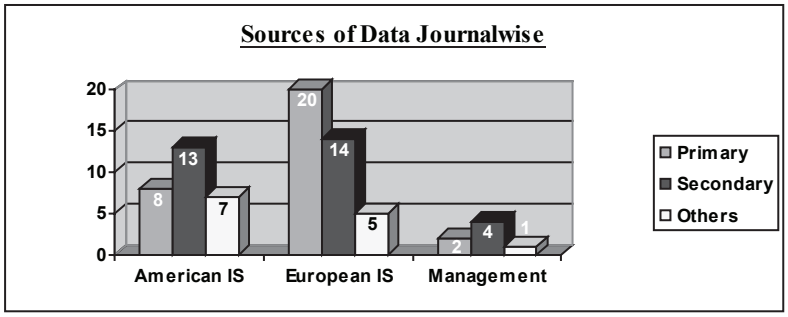
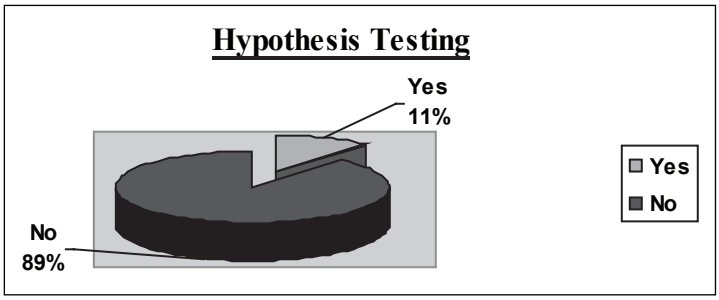


Figure 14.



five other sources articles. The management journals had two primary data sources articles, four secondary data sources articles, and one 'other' sources article. European journals mainly relied on primary data sources, whereas the American and management science journals relied on secondary data sources (see Figure 13).

Hypothesis Testing

Eight articles indicated hypotheses testing out of the 70 articles reviewed (see Figure 14). The American IS journals had five articles indicating hypotheses testing, the European IS journals had two articles involving hypotheses testing, and the management journals had one article indicating hypotheses testing. Thus the American journals indicated a greater trend towards hypothesis testing than the European journals (see Figure 15).

Data Analysis Techniques

There were 28 articles which indicated descriptive analysis, nine involving applied regression,

Figure 15.

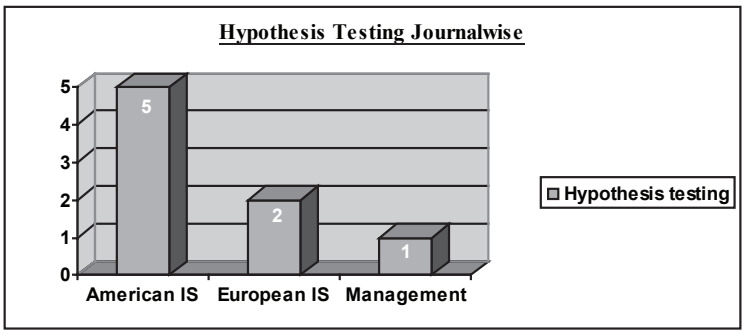


Figure 16.

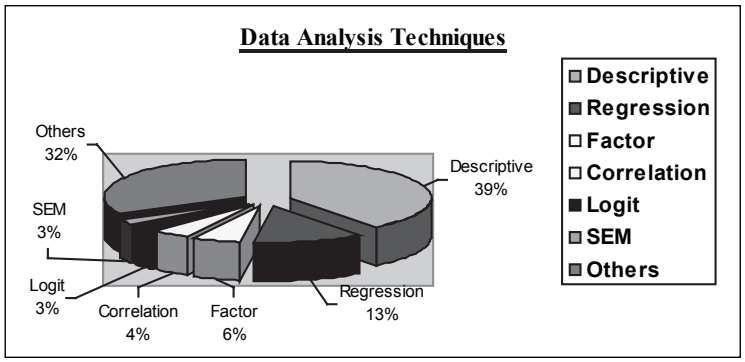
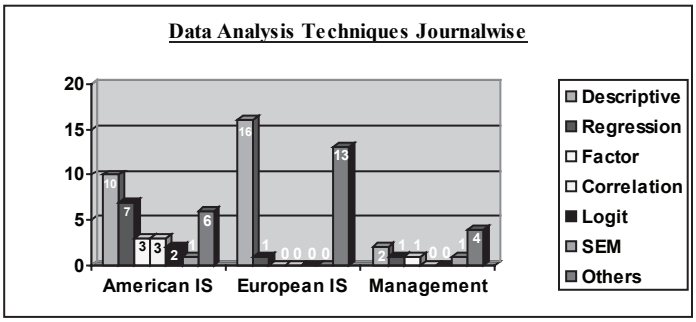


Figure 17.



four involving factor analysis, three involving correlation, two indicating Logit model, two involving structural equation modeling, and 23 under the 'others' category (see Figure 16). There were no articles applying cluster analysis, conjoint analysis, and path analysis. The 'others' category involved qualitative analysis of interview transcripts. American journals applied higher quantitative statistical analysis techniques whereas the European journals were restricted to mainly descriptive and qualitative techniques (see Figure 17).

Paradigmatic Representations

The paradigmatic analysis for IS and BP outsourcing research in 70 papers using the operations

research paradigm framework is tabulated in Figure 18.

The literature review highlighted that the American journals are predominantly positivist in approach, but the results show that in the area of IS and BP outsourcing, they are also adopting interpretive paradigms. Although American journals are still more inclined towards positivism (positivist and axiomatic—11 articles), the trend towards interpretive research (nine articles) is evident. The European journals belong predominantly to the interpretive paradigm (interpretive—30 articles; positivist and axiomatic—seven articles).

IMPLICATIONS

Analysis of previous review papers in IS research highlights that positivist paradigm holds a dominant position. A paper by Galliers and Meadow (2003) offers a possible explanation in this regard. They discovered that editorial board members of

Figure 18.

	Direct Observation Of Object Reality	People's Perceptions Of Object Reality	Artificial Reconstruction Of Object Reality
AXIOMATIC			American Journals: • *JMIS* (3) Management Journals • *MS* (4) • *DS* (1) European Journals: • *JIT* (1)
LOGICAL POSITIVIST/ EMPIRICIST		American Journals: • *ISR* (3) • *MISQ* (2) • *JMIS* (3) Management Journals • *MS* (1) • *DS* (1) European Journals: • *JIT* (4)	European Journals: • *EMJ* (2)
INTERPRETIVE	American Journals: • *MISQ* (2) European Journals: • *JIT* (2) • *EJIS* (6) • *EMJ* (6)	American Journals: • *ISR* (2) • *JMIS* (4) Management Journals • *MS* (1) European Journals: • *JIT* (5) • *EJIS* (2) • *EMJ* (9)	American Journals: • *MISQ* (1)
CRITICAL THEORY			

North American journals like *ISR* and *MISQ* were primarily North American researchers (between 75% and 87.5% for *ISR,* and 51.2% and 86.8% for *MISQ*), and these journals tended to publish articles written by North American researchers (74% for *ISR* and 83% for *MISQ*). A similar situation was reported for European journals where the editorial board members were largely European, as were the papers published (Galliers & Meadow, 2003; Chen & Hirschheim, 2004). Galliers and Meadow (2003) concluded that the IS field maintained a "homegrown" perspective. Further, traditional wisdom has long recognized that positivist research is more easily accepted because its research tradition has been more successfully established (Hirschheim & Klein, 2002). The mainstream North American journal, *MISQ,* had publicly announced its acceptance of alternate research approaches in 1993. Chen and Hirschheim (2004) reported from their empirical analysis of 1,893 articles that even after years of advocacy of paradigmatic pluralism, not much has changed. On the contrary our findings indicate that a change is noticeable as the American journals—though still more inclined towards positivism (positivist and axiomatic—11 articles)—are also publishing interpretive research (nine articles). However, this can also be attributed to the recency of the phenomenon of outsourcing.

Another interesting observation is that highlighted by the comparison between empirical and non-empirical studies. Our analysis revealed that 66% of the papers were empirical in nature. Chen and Hirschheim (2004) have also reported that researchers have increased their use of empirical data collection. Interestingly, our study revealed that the American journals had an equal balance of empirical and non-empirical articles whereas the European journals indicated applying mostly the empirical approach. Chen and Hirschheim (2004) state that as a field matures, theoretical and conceptual developments become less appealing, and empirical studies become more popular because of the need for theory testing and practical relevance. The European journals indicated more research in the outsourcing field (58%) as compared to the American journals (29%). For this reason the European journals could possibly regard outsourcing research as a mature field and show greater adoption of empirical studies.

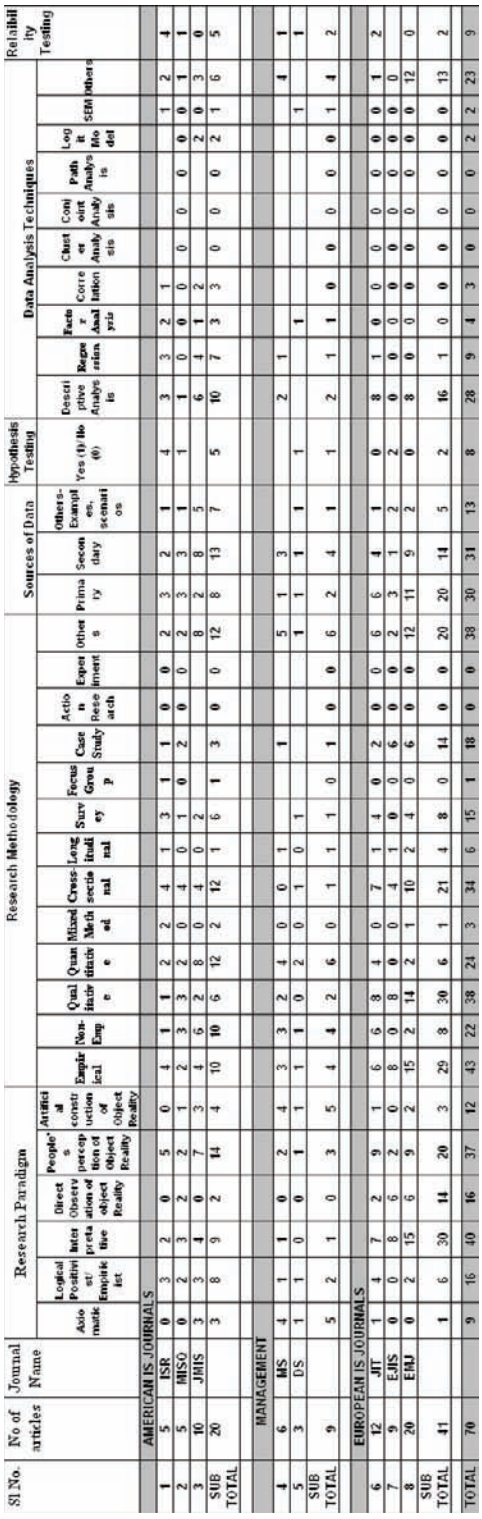
Both the American and European journals mainly involved cross-sectional studies. Longitudinal approach was insignificant in quantum. It can be due to the contention that cross-sectional studies enjoyed more popular positions (Chen & Hirschheim, 2004) and prevalence of a 'publish or perish' research publication notion (Walsham, 1995). Also, research using literature reviews, conceptual model building, mathematical model building, and research commentaries were the most predominant research designs followed by case study and survey research. The European journals mainly relied on primary data sources whereas the American journals relied more on secondary data sources. Finally, the American journals applied higher quantitative statistical analysis techniques and indicated a greater trend towards hypothesis testing, whereas the European journals applied mainly descriptive and qualitative techniques.

To summarize, this study reveals that in the area of outsourcing, interpretive paradigm is beginning to dominate if two sides of the Atlantic are put together. This can probably be attributed to the reality that European journals are publishing more in this area and they are more interpretively inclined. Newness of outsourcing could also be one possible explanation as the more positivist inclined American journals were also reporting interpretive research in this area.

DIRECTIONS FOR FUTURE RESEARCH

The IS and BP outsourcing industry is poised for phenomenal growth, and this area has high potential for future research. Outsourcing has

Figure 19 presents the summary of data based upon methodological and paradigmatic representations.



Sl No.	No of articles	Journal Name	Research Paradigm						Research Methodology														Sources of Data			Hypothesis Testing	Data Analysis Techniques											Reliability Testing
			Axiomatic	Logical Positivist/ Empiricist	Interpretative	Direct Observation of object Object Reality	People's perception of object Reality	Artificial construction of Object Reality	Empirical	Non-Emp	Qualitative	Quantitative	Mixed Method	Cross-sectional	Longitudinal	Survey	Focus Group	Case Study	Action Research	Experiment	Others	Primary	Secondary	Others-Examples, scenarios	Yes (t) No (ϕ)	Descriptive Analysis	Regression	Factor Analysis	Correlation	Chuster Analysis	Coinoint Analysis	Path Analysis	Log it Model	SEM	Others	
		AMERICAN IS JOURNALS																																			
1	5	ISR	0	3	2	0	5	0	4	1	1	2	2	4	1	3	1	1	0	0	2	3	2	1	4	3	3	2	1				1	2	4
2	5	MISQ	0	2	3	2	2	1	2	3	3	2	0	4	0	1	0	2	0	0	2	3	3	1	1	1	0	0	0	0	0	0	0	1	1
3	10	JMIS	3	3	4	0	7	3	4	6	2	8	0	4	0	2					8	2	8	5		6	4	1	2				2	0	3	0
SUB TOTAL	20		3	8	9	2	14	4	10	10	6	12	2	12	1	6	1	3	0	0	12	8	13	7	5	10	7	3	0	0	0	2	1	6	5
		MANAGEMENT																																			
4	6	MS	4	1	1	0	2	4	3	3	2	4	0	0	1			1			5	1	3			2	1							4	1	
5	3	OS	1	1	0	0	1	1	1	1	0	2	0	1	0	1					1	1	1	1	1			1					1		1	
SUB TOTAL	9		5	2	1	0	3	5	4	4	2	6	0	1	1	1	0	1	0	0	6	2	4	1	1	2	1	1	0	0	0	1	4	2	
		EUROPEAN IS JOURNALS																																			
6	12	JIT	1	4	7	2	9	1	6	6	8	4	0	7	1	4	0	2	0	0	6	6	4	1	0	8	1	0	0	0	0	0	0	1	2
7	9	EJIS	0	0	8	6	2	0	8	0	0	8	0	4	1	0	0	6	0	0	2	3	1	2	2	0	0	0	0	0	0	0	0	0	
8	20	EMJ	0	2	15	6	9	2	15	2	14	2	1	10	2	4	0	6	0	0	12	11	9	2	0	8	0	0	0	0	0	0	0	12	0
SUB TOTAL	41		1	6	30	11	20	3	29	8	30	6	1	21	4	8	0	14	0	0	20	20	14	5	2	16	1	0	0	0	0	0	0	13	2
TOTAL	70		9	16	40	16	37	12	43	22	38	21	3	34	6	15	1	18	0	0	38	30	31	13	8	28	9	4	3	0	0	0	2	2	9

emerged as a multifaceted subject. There is a great deal of diversity in terms of research objectives, theoretical foundations, and methods (Dibbern et al., 2004). Additional exploratory content analysis of the papers revealed various emerging research areas. These are summarized as follows:

- **Longitudinal studies:** An evident need for longitudinal studies is a key finding of this study. There is an opportunity for researchers to move beyond the snapshot studies and broaden the perspective of outsourcing by incorporating temporal effects to answer questions like, How does the outsourcing process change over time?
- **Client-vendor relationships:** An in-depth understanding of the key issues underlying client-vendor relationships is required. Most of the studies were from the client perspective, and there was a need for further examining the vendor perspective. Additionally, dyadic studies incorporating both the client and vendor perspective would offer better understanding of the dynamics of such engagements.
- **Client-vendor governance arrangements:** An increasing number of varied outsourcing contracts have increased the complexities of governance mechanisms. There is a need to explore such engagements and understand the dynamics of control. Additionally, the impact of informal relationship between the client and vendor organizations can lead to interesting studies. There is an emerging nature of such relationships. This promising trend to move beyond the contractual engagements can be explored. What is the impact of trust on the governance of such arrangements? How does an outsourcing contract-relationship evolve over time?
- **Risk management:** Turning over the entire business process to a vendor brings with itself various risks. Studies conceptualizing and examining comprehensive risk assessment

frameworks can aid in better understanding the dynamics of outsourcing risks.

- **Operationalization and measurement of outsourcing success:** Success is defined differently in various papers by various stakeholders and researchers. The complicated nature of the perception of success makes it a difficult variable to operationalize. Hence an all-inclusive view of success can be explored.
- **Emerging role of countries:** The emerging role of countries—like India, China, the Philippines, and others—from cost-saving outsourcing destinations to strategic value-adding outsourcing destinations is also a fertile area for future research.

Furthermore, the dataset of this research was limited to eight journals only. Hence this study can be taken forward by researchers for larger assessment by including other management science journals in the area of information systems, operations, human resources, organizational behavior, finance, and strategy.

CONCLUSION

The purpose of this article was to study the literature on IS and BP outsourcing using a methodological and paradigmatic lens. The analysis of publication trends brings out a growing awareness of non-positivist approaches to doing research in outsourcing. However, the analysis also brings out a continuing divide across the Atlantic Ocean. The authors hope that awareness of such a divide would trigger a meaningful dialogue over the underlying perspectives so that it stimulates more wholesome research across the globe. A better balance between the positivist and interpretive is also likely to save us from making unnecessary blunders due to cultural blindness of the positivist paradigm in the outsourcing phenomenon, which by its very nature straddles far-flung continents and cultural worlds. The analysis also shows the paucity of longitudinal and action research studies, which actually have great potential to generate deeper insights about the challenges to the management of outsourcing. In sum, the article attempts to stimulate a reflective introspection in the research community interested in the emerging phenomenon of outsourcing.

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APPENDIX

The Meredith model has two continuums that enable categorization of research based upon the underlying tenets of its methodology-the Rational Vs Existential (R/E) and the Natural Vs Artificial (N/A).

NATURE OF TRUTH	KIND OF INFORMATION USED: NATURAL ← → ARTIFICIAL	Direct Observation of Object Reality	Peoples preceptions of Object Reality	Artificial Reconstruction of Object Reality
RATIONAL	**Axiomatic**			Reason/Logic/Theorems, Normative Modelling and Descriptive Modelling
	Logical Positivist/ Empiricist	Field Experiments and Field Studies	Structured Interviewing and Survey Research	Prototyping, Simulation, Laboratory Experiments
	Interpretive	Action Research and Case Studies	Historical Analysis, Expert Panels, Delphi and intensive interviewing	Conceptual Modelling and Hermeneutics
EXISTENTIAL	**Critical Theory**		Introspective Reflection	

At one extreme is **Rationalism**, which uses a formal structure and pure logic as the ultimate measure of truth. At the other extreme is **Existentialism**, the stance that knowledge is acquired through the human process of interacting with the environment. **Rational/Existential** dimension includes four generic perspectives that structure the research by different degrees of formalism. These four perspectives, in order of degree of formal structure, are axiomatic, logical positivist/empiricist, interpretive, and critical theory. The **Axiomatic** perspective represents the theorem-proof world of research. The **Logical Positivist/Empiricis**t perspective assumes that the phenomenon under study can be isolated from the context in which it occurs and that facts or observations are independent of the laws and theories used to explain them. This is the basis for most survey research. The **Interpretive** perspective includes the context of the phenomenon as part of the object of study. Interpretive researchers study people rather than objects, with a focus on meanings and interpretations rather than behavior. **Critical Theory** is a recent influential contribution to post-positivist thought. The critical theory perspective is an attempt to synthesize the positivist and interpretive perspectives and get past their dichotomy by placing knowledge in a broader context of its contribution to social evolution.

This second dimension concerns the source and kind of information used in the research. At the natural end of the continuum is empiricism (deriving explanation from concrete, objective data), while at the artificial end is subjectivism (deriving explanation from interpretation and artificial reconstruction of reality). **Object reality refers to direct observation** by the researcher of the phenomenon. It assumes that there is an objective reality and that human senses can detect it. It corresponds to the pure empiricism extreme. As with the other categories, the observation may be subjected to formal structured analysis (or axiomatisation, as in econometric studies) or to interpretation using critical theory. **People's perceptions of object reality** relate to research conducted "through somebody else's eyes," as in surveys, interviews, or many laboratory experiments. Thus, the primary concern is with the perception or abstract representation of the reality of individuals exposed to the phenomenon. **An artificial reconstruction of object reality** is attempted in almost all the modeling and systems analytic efforts in operations. These approaches recast the object reality, as originally determined from one of the above two categories (usually the researcher's own belief concerning the object reality), into another form that is more appropriate for testing and experimentation, such as analytical models, computer simulations, or information constructs.

Source: Adapted from Meredith *et al.* (1989)

This work was previously published in the Information Resources Management Journal, Vol. 21, Issue 1, edited by M. Khosrow-Pour, pp. 27-43, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 2
Outsourcing in the Healthcare Industry:
Information Technology, Intellectual Property, and Allied Aspects

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ABSTRACT

The healthcare industry is being impacted by advances in information technology in four major ways: first, a broad spectrum of tasks that were previously done manually can now be performed by computers; second, some tasks can be outsourced to other countries using inexpensive communications technology; third, longitudinal and societal healthcare data can now be analyzed in acceptable periods of time; and fourth, the best medical expertise can sometimes be made available without the need to transport the patient to the doctor or vice versa. The healthcare industry will increasingly use a portfolio approach comprised of three closely-coordinated components seamlessly interwoven together: healthcare tasks performed by humans on-site; healthcare tasks performed by humans off-site, including tasks performed in other countries; and healthcare tasks performed by computers without direct human involvement. Finally, this paper deals with intellectual property and legal aspects related to the three-pronged health-care services paradigm.

INTRODUCTION

Advances in computing and communications technologies are dramatically altering the healthcare landscape around the world in a number of ways such as:

- enabling detailed analysis of healthcare data to elicit underlying trends and interrelationships;
- facilitating storage, transmission, integration, and retrieval of healthcare records;
- enabling healthcare professionals to render assistance to patients separated by significant geographic distance from each other;
- monitoring the safety of medical procedures and pharmaceutical drugs; and
- bringing the latest healthcare information to the attention of healthcare professionals and others.

In this article, we take five operational scenarios, one from each of the five illustrative categories delineated above. In each operational scenario, at least one of the co-authors of this article played a significant role and therefore possesses first-hand knowledge of that healthcare application. The operational scenario is analyzed, post-facto, from the viewpoint of diagnosing what subset of tasks can be handled by evolving information technologies without significant human intervention, what subset needs to be performed on-site by humans, both now and in the foreseeable future, and what subset can be potentially performed by humans located at a significant distance from the patient.

Based on the above analysis, we postulate that the future healthcare industry is unlikely to adopt a mono-operational scenario in which all the tasks occur on-site (as happened in the past), off-site, or by machines alone. Instead, the healthcare industry will gradually adopt an operational model in which there is a seamless and symbiotic combination of all three modes of operation.

After examining the future healthcare industry model from multiple perspectives, we conclude that we need a new approach to intellectual property in order to adequately safeguard the interests of the relevant constituencies. Based on the forces that will motivate the change, we further assert that healthcare organizations that are unwilling to adapt and embrace the evolving three-faceted work paradigm will be at a competitive disadvantage to their peers. National, state, and local medical regulatory agencies will need to respond to market pressures in order to support the long-term interests of both medical professionals and patients in their respective jurisdictions.

COMPREHENSIVE ANALYSIS OF HEALTHCARE DATA

One out of eight women in the United States will develop breast cancer during her lifetime. Early detection is a woman's best defense against breast cancer, which is 97% curable when detected and treated at an early stage. Mammography is the gold standard for screening for breast cancer. With the trend towards people living longer lives and taking proactive measures on their health, the demand for mammography is increasing at a significant pace. Unfortunately, 10-20% of the cancers currently detectable by a screening mammogram are missed by the human radiologist, allowing the disease another year to progress. In addition, there is a high degree of liability on radiologists due to missed diagnoses. To mitigate this problem, some radiology screening centers employ two radiologists to read each case. This approach involves significant cost to support an additional radiologist, reduces the number of total mammograms that can be performed within a center, and is problematic due to the shrinking numbers of radiologists in the field of mammography, especially in the United States.

Based on the latest information available on the FDA Web site (October 2006), there were

8,832 FDA-certified mammography centers and 13,511 accredited units in the United States. In the year 2006, there were 34.6 million mammograms performed in the United States alone, which translates into a total market of $5 billion (at $150 per mammogram). Globally, there are over 200 million mammograms per year, which translates to a market running into several billions of dollars per annum. As the population of women over 40 increases and the awareness of proactive health measures, such as mammograms, gets enhanced, the number of mammograms increases every year. However, a decrease in mammogram centers and the number of radiologists in this field are negatively correlated with the demand.

The area of mammography and the aspect of errors in diagnosis (both false positives and false negatives) have been studied in detail by many researchers (Berlin, 2005; Ghate et al., 2005; Gilbert et al.; 2006; Khoo, Taylor, & Given-Wilson, 2005; Sickles, Wolverton, & Dee, 2002; Skaane, Kshirsagar, Stapleton, Young, & Castellin, 2006).

The use of computer-aided detection (CAD) techniques in mammography can mitigate the growing shortage of radiologists, as well as reduce or eliminate many of the instances of missed diagnosis. One of the authors of this article and several of his colleagues have developed new computer-based algorithms that allow a rapid analysis leading to the marking of cancerous and pre-cancerous regions, thereby providing a decision-support diagnostic facility to the radiologist. Using a CAD-based approach in conjunction with a human radiologist allows for the second reading of a mammogram, with the human radiologist actively involved in the process and making the final determination in each case. The advantages of the proposed approach are:

- The capital investment of using a CAD service is significantly less, when compared to that of employing a second radiologist.
- No additional hardware or space requirements are required.
- Current and previous cases can be made available to the radiologist online for necessary comparison.
- There is a minimal footprint in the workspace, allowing multiple radiologists to objectively view and analyze mammograms.
- Results and information can be made available anywhere via the Internet.
- Improvements to the algorithm and core technology can be readily disseminated.
- The approach is consistent with the trend towards teleradiology, allowing radiologists to perform analysis from anywhere, anytime.
- The proposed approach reduces the incidence of second visits and the level of patient anxiety by providing expert (specialty) second opinions when needed in a timely manner through a teleradiology model.

The proposed approach was developed in 2001 and 2002 (Gupta, Norman, Mehta, & Benghiat, 2002), and its technology component is described in Norman and Gupta (2002), which advocated that instead of taking the mammogram image and its interpretation by the radiologist at the same location, it would be more advantageous to use a geographically decentralized strategy that utilized the following principles:

- taking of the mammogram image by a technician at the location where the patient was available;
- transmitting the image to a central location where the image was analyzed by advanced data mining techniques and compared with other images;
- interpretation by a qualified radiologist at the same location where the centralized computing facility is located or at a different place altogether; and

- making the image available, with appropriate privacy and security safeguards, to the patient when she visits other clinics and to appropriate medical personnel with the patient's consent.

Based on unique and patentable distributed computing technology, a peer-to-peer model was implemented; it could act as a pure application service provider (ASP), a pure client application, or any combination in between. The proposed solution could:

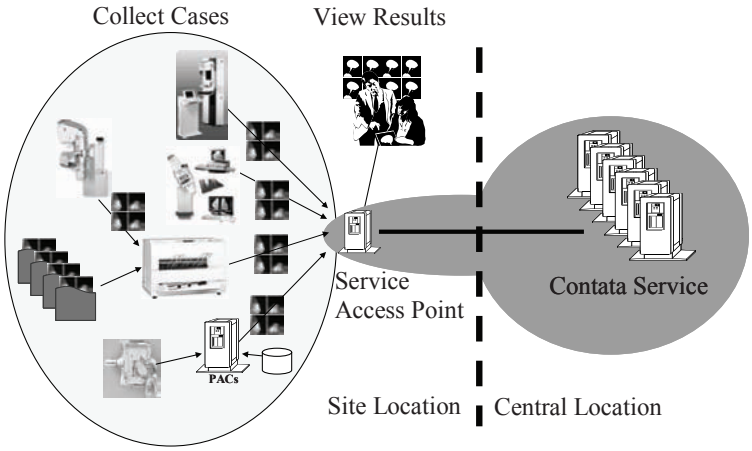
- minimize or eliminate the costs of a "second reader";
- provide scalability for large, medium, and small centers (national and international);
- support the development of distributed teleradiology systems;
- decrease the liability factor for false readings; and
- improve equity of access to radiology services by employing only technicians on-site and performing both human and CAD readings off-site.

The proposed technology envisaged a long-term vision of "Image Anywhere." where there is a network of mammography screening centers in shopping malls across the country. A woman could step into a mammography center as easily as walking into a drug store. While the screening was performed at that site, the radiologist could be located hundreds of miles away looking at images from several mammography centers (via teleradiology) and could provide an opinion back to the concerned location within a few minutes of the screening time.

Finally, the proposed architecture and the technology could be readily adopted for use with all other types of medical images, as depicted in Figure 1. After establishing a track record with mammography CAD, the plan envisaged expansion into auxiliary applications (first medical, then non-medical). These include dentistry, CT colonography, and bone cancer detection.

The above concept was unanimously voted to be the first-place winner at the Big Red Venture Fund Innovation Contest, organized on an annual basis by Cornell University (2002). To the best of the authors' knowledge, this is the pioneer instance where the three-pronged strategy of using resident medical resources, off-site medical resources,

Figure 1. The integrated architecture for the use of on-site medical personnel, off-site medical personnel, and computer-based techniques for mammography and other medical applications



and advanced computational techniques was explicitly delineated; this was done in the context of optimizing the productivity of radiologists, enhancing access to mammography centers by women, improving the quality of interpretation of mammograms, reducing the incidence of errors (both false positives and false negatives), and reducing the costs incurred in performing mammograms.

MANAGEMENT OF HEALTHCARE RECORDS

As healthcare costs continue to rise, researchers are exploring new options for enhancing the process of sharing medical data across disparate information systems, both within and across hospitals and other healthcare facilities. This has the potential to reduce costs by billions of dollars each year, estimated at $77.8 billion for the United States alone (Walker et al., 2005), and concurrently improve the quality of healthcare rendered to patients. Each of the entities in the current generation of hospital systems was built to function on an individual basis, with each island of information governed by its own idiosyncratic data model (Shortliffe, 1998). In the U.S., only regional interoperability has been implemented, so far, on an experimental basis (Halamka et al., 2005). The absence of a larger-scale interoperable system presents other problems too. For example, in the case of a plane crash or other catastrophic situation, the manual approach to accessing large numbers of patient records is very weak (Teich, Wagner, Mackenzie, & Schafer, 2002). There are several other facts that further strengthen the requirement for interoperable healthcare systems, such as:

1. There is a large number of cases where institutions have split or merged, and existing data are physically distributed.
2. There are several 'mobile' individuals who frequently use medical facilities in different states or even countries.
3. The aged population contribute significantly to overall healthcare costs and very often have limited mobility.

This increases the requirement of access to healthcare records from a previous residence or transmittal of medical data to remote facilities for diagnosis rather than to move the patients themselves.

The challenges inherent in transforming disparate islands of data into an archipelago of integrated information have been highlighted by Gupta (1988) and others (Reddy, Prasad, Reddy, & Gupta, 1994; Arellano & Weber, 1998; Arts, Keizer, & Scheffer, 2002). The constituent systems differ in terms of data types, data definitions, data structures, data hierarchies, data categorizations, and underlying assumptions that are not expressly denoted in the concerned information systems. Imagine that you receive an electronic medical record of a new patient. The weight of the person as shown in the corresponding database field is 75. If you are a medical professional in the United States, your immediate reaction is that the person is extremely underweight, based on the assumption that weight is specified in pounds, whereas it is actually in kilograms. The U.S. is among the handful of countries that still use the traditional British system for most measurements; another county in this category are in Africa. Britain moved to the metric system a few decades ago. Ironically, the healthcare arena is the only one where the metric system has been adopted in the U.S. for measurement of mass and volume. However, many other types of differences continue to remain in terms of underlying assumptions of data types and other parameters; such assumptions are not revealed by looking at the data alone.

The above example highlights that healthcare data must often be converted from one form into another to facilitate communication, either

at the source or at the destination. The process of conversion of data, manually or by computer, involves significant costs and is prone to the loss of information (Barthell, Coonan, Pollock, & Cochrane, 2004; Shapiro et al., 2006). Since many healthcare applications require access to each other's data, and neither the source nor the destination is willing to do the required conversions, the only possible solution is to transform the data en route from the source to the destination.

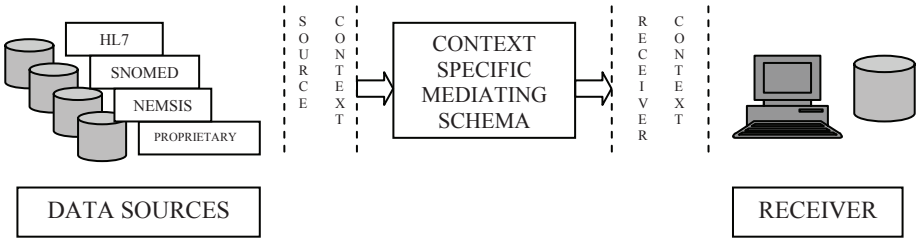
The format and other details related to the data at the source are maintained in the source schema. The target schema contains the same types of underlying information for the destination. As the number of potential sources and potential targets increase, the number of likely transformations increases in a non-linear fashion. Haas, Miller, Niswonger, Roth, and Wimmers (1997), Milo and Zohar (1998), Abiteboul, Cluet, and Milo (2002), and Shaker, Mork, Barclay, and Tarczy-Hornoch (2002) advocated the use of middleware and the use of one common schema that incorporates data elements from multiple client schemas. The complexity of this common schema increases with the number of sources and targets, thereby restricting the use of this approach in large, diverse healthcare applications.

Wiederhold and Genesereth (1997) highlighted the fact that a single mediating schema in a large domain such as healthcare is not feasible; they advocated that the implementation of domain-specific data standards and mediators across heterogeneous medical information systems results in a cost decrease for mediating the transfer of data. Despite these findings, there is minimal standardization in the creation of healthcare information systems in the United States and in many other countries. This means, for example, that if there are "m" ambulance systems and "n" emergency department systems that could potentially need the medical data from any of the "m" ambulance systems, one could be dealing with as many as "m multiplied by n" transformations of data. Given the complexity of dealing with such a large number of possibilities, the process of data transformation is clumsy, time consuming, and costly (Gupta, 1998).

One approach to address the above problem of non-linearity is to create a mediating schema as the framework for reconciling heterogeneous information systems within and across hospitals and other healthcare facilities. Using the approach described in several papers, including Reddy and Gupta (1995), the number of necessary transformations can be reduced from "m x n" to "m + n". This requires that the mediating schema contain a core set of context-specific patient care-related information and a comprehensive methodology for specifying the ontology (vocabulary) of the relevant healthcare domain. The lattice-based context interchange approach, described by Reddy and Gupta (1995), allows evolutions of the semantics of data in the source or target schemas to be managed in a more effective manner as compared to traditional approaches. Differences in ontology always exist in large information systems (Wiederhold & Genesereth, 1997). Within a single hospital, each healthcare unit may collect, store, and process its own set of data, based on its own specialty and needs. The application of the mediating schema approach requires the careful study of the different ontologies, and the formulation of rules to transform data from one particular ontology to another.

Sarnikar and Gupta (2007) describe the problems and challenges involved in creating a mediating schema that would transfer data between the heterogeneous databases of a particular pre-hospital and ED system in the Boston area, and in extending the prototype system to cater to the idiosyncrasies of additional medical systems (see Figure 2). Based on the assessment of the size and complexity of the source and destination databases, as well as the associated data dictionaries, it was concluded that the mappings between single data elements needed to be done manually. This was based on the realization that the available software approaches to automate

Figure 2. The use of the mediation approach to reduce the effort involved in integration data from heterogeneous information systems (adapted from Sarnikar & Gupta, 2007)



the mapping process between databases were frequently unreliable and required human intervention to analyze and to make corrections to the mappings generated. The manual creation of mappings could, however, lead to a set of development rules that could facilitate the creation of additional schemas in the future.

These tasks involved extensive consultation between members of the development team and experts from several concerned medical specialties, especially for "analysis of what information most succinctly and completely composed the patient care record across the source and target hospital information systems." The analysis of the data elements involved acquiring deep understanding of the meaning of each element in the source schema and its corresponding element in the target schema, as well as the associated differences in cardinality.

Sarnikar and Gupta (2007) presented a performance analysis of the above system in terms of information loss during the automated data translation process, relative to the coverage (amount of fields populated in the target schema using information from the source schema). Due to the presence of certain type conflicts and missing-data conflicts, a small amount of information was lost (<15%) in the presence of significant coverage values (>80%). Further, this was eliminated through the use of appropriate converters and filters (Gaynor, Gupta, Rawn, & Moulton, 2008; Gupta Martin, Avanavadi, & Sarnikar, 2007).

Industries and applications that are still at an evolutionary stage are frequently characterized by the existence of no standards or by the existence of too many standards, none of which carry broad acceptance. In the case of the healthcare arena, multiple standards currently exist, including HL7, EDIFACT, X12, ASTM, NCPDP, DICOM, and XDT (Dudeck, 1998). Further, as a reviewer of this article pointed out, the need for the transmission of medical data may be acute, sub-acute, or delayed. The electronic transmission of acute data (pre-hospital to emergency department) usually occurs in the case of healthcare providers who can use a common data set for their medical records. Sub-acute transmission could apply in situations involving hospitals and providers who use similar data elements, but not necessarily a similar platform. Delayed transmission, such as transmission of data across a national boundary, will need a standardized healthcare language, but not common data elements or platforms.

Based on the above discussion, we find that the use of cutting-edge computer and communications technology alone cannot accomplish the goal. Instead, large amounts of computational power and human expertise are needed to create the bridges across legacy healthcare information systems at this stage. Hospitals and other healthcare facilities in the U.S. have traditionally used medical and information technology personnel in the U.S. to undertake initial efforts in this area. Unfortunately, a vast majority of work remains

to be done, and this cannot be accomplished, in terms of both time and costs, by the personnel available in the U.S. As such, one needs to explore non-conventional solutions that involve the use of resources from abroad.

Until the eighties and the nineties, large U.S. companies belonging to other sectors of the economy focused on doing all of their information technology work in the U.S. (Gupta, Seshasai, Mukherji, & Ganguly, 2007b). This was the traditional model, and the concerned management and technical personnel were satisfied with the pace of progress. Options for doing such work abroad, or by persons recruited from abroad for temporary work in the U.S., were frequently discarded on the basis that:

1. Only the persons currently associated with the work were familiar with the intricacies involved, thereby implying that such peculiarities were too complex or too confidential to be shared with others.
2. Organizational procedures or governmental regulations did not permit data and process information to be transmitted abroad or shown to foreign nationals.
3. The concerned work was too important for the success of the company, and the option of saving costs on this particular application was miniscule in comparison.
4. The work could not be performed by persons working in Asia because the difference in time zones made it impossible for them to interact with domain experts in the U.S.

The above situation was dramatically altered by the Y2K dilemma. Management and technical personnel could no longer plead for six more months to complete a project. The date, December 31, 1999, was a very hard deadline, and the conversion of information systems had to be completed by then: no exceptions, indeed. This inflexible scenario forced the companies to become flexible. They permitted parts of the conversion work to be done abroad, as well as to employ persons with foreign qualifications and experience. The conversion from national currencies to the common currency, euro, had a similar impact in Europe. The unqualified success in both cases forced companies to depart from their arrogance in maintaining status quo.

A similar compelling need currently exists in the case of management of healthcare records. Conventional database systems are clumsy, costly, and time consuming. The integration of information in such systems, as well as the gradual incorporation of newer concepts, requires the healthcare industry to seriously consider the use of the hybrid model, involving the use of human resources in the U.S., human resources abroad, and state-of-the-art information technology. The success of the banking industry, the insurance industry, and several other industries too relies heavily on ensuring the privacy and the security of data belonging to their customers. Yes, glitches do happen from time to time. In 2004, information on 20 million credit card holders was compromised at a credit card processing facility in Tucson, Arizona. This particular facility was subsequently acquired by another company. But this unauthorized disclosure was not used as the basis to cease this type of application altogether. Instead, it should serve as the motivator for human experts, both in the U.S. and abroad, to develop more robust applications that can be used by more industries.

REMOTE DIAGNOSIS

Remote diagnosis is both an outsourcing and an insourcing phenomenon. For many years, medical records and medical images from patients and healthcare practitioners in Latin American countries, as well as from other countries in the world, have been reviewed by doctors at Massachusetts General Hospital in Boston and by a number of other leading hospitals in the U.S. The Arizona

Telemedicine Program (ATP) is a pioneer in terms of medical professionals located in Tucson, Arizona, providing expert advice to patients located elsewhere in the state, in neighboring states, and in other countries. ATP provides teleradiology, telepathology, and teleoncology services to patients in hospitals, in prisons, and in other settings (Weinstein et al., 2007). A significant number of the patients, who seek remote diagnostic advice, are from Navajo Nation and from other Native American nations in Arizona and neighboring states of the U.S.

On the outsourcing side, medical personnel in other countries are looking at medical records of patients in the U.S. The specialty that has witnessed the most attention is teleradiology (Pollack, 2003). Teleradiology involves the electronic transmission of radiological images, such as X-rays, computed tomograms, and magnetic resonance images, across geographical locations via telephone lines, satellite connections, and wide area networks. It enables a single radiologist to serve multiple hospitals concurrently, even ones in other continents. Further, it enables the image to be interpreted by an alert physician working a day shift rather than a radiologist who has been up all night (Weinger & Ancoli-Israel, 2002; Firth-Cozens & Cording, 2004).

Telemedicine is the delivery of healthcare services in situations where the physician and the patient are not at the same geographic location; it is a broad term and includes teleradiology, telepathology, and teleoncology. Telepathology involves the use of video microscopy at the patient's location and a pathologist's workstation at the physician's location. Teleoncology refers to the use of remote technology to address different aspects of cancer care.

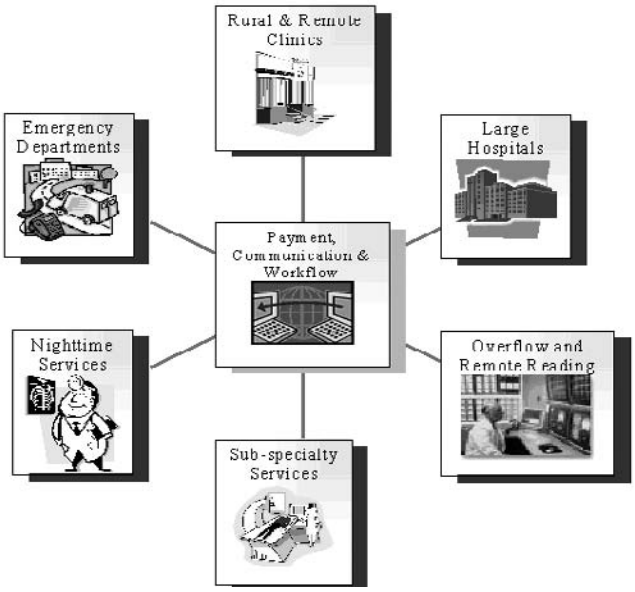
For the purposes of studying "remote diagnosis," we will focus primarily on teleradiology for four reasons. First, the area of teleradiology has attracted wide attention in the media (e.g., Pollack, 2003). Second, this article focuses on outsourcing rather than insourcing, and the other specialties are characterized more by insourcing than by outsourcing. Third, within outsourcing, we are focusing on offshoring issues and are looking at applications that transcend national boundaries, not just local or state boundaries. Fourth, the teleradiology scenario allows an objective assessment of the potential risks and opportunities for individual radiologists in the U.S., as well as for the broader medical community in the U.S.

The growth in teleradiology is being driven by four major forces. First, there is a significant shortage of radiologists, because of a significant number of radiologists retiring from practice and training programs not keeping pace with growing demand (Sunshine, Maynard, Paros, & Forman, 2004; Bhargavan & Sunshine, 2002). Second, the aging population and the advent of newer imaging technologies are leading to annual increases in imaging volumes; for example, a 13% increase in the utilization of radiological imaging was observed among Medicare beneficiaries (Maitino, Levin, Parker, Rao, & Sunshine, 2003). Third, the increased use of imaging technologies in trauma situations has led to a corresponding need for round-the-clock radiological services in hospital emergency rooms (Spigos, Freedy, & Mueller, 1996). Fourth, changing regulations and guidelines have contributed to the need; as an example, the Health Care Financing Administration (HCFA) requires that overnight coverage be provided by certified radiologists, rather than by residents or trainees, in order to be billable (HCFA Medicare Program, 1995).

Typically, the radiology group outsources its night calls to a teleradiology provider and pays the latter for preparing the preliminary report. The insurer is billed for the final report that is prepared by the radiology group the following morning. The service delivery model depicted in Figure 3 includes mechanisms for communications, workflow, and payments.

Teleradiology offers several advantages:

Figure 3. A service delivery model for teleradiology (adapted from Kalyanpur, Latif, Saini, & Sarnikar, 2007)



1. A single professional can support multiple hospitals concurrently via teleradiology links to a central reading facility (often the radiologist's home).
2. Remote locations with radiological scanning, but no on-site radiologist, can be supported leading to improved patient care (Franken et al., 1995; Lee et al., 1998).
3. The productivity of the radiologist can be enhanced by bringing the images to the radiologist, rather than vice versa, thereby eliminating commuting time and delays.
4. The work can be optimally assigned among multiple radiologists in large hospitals.
5. Greater availability of subspecialty consultations results in better patient care (Kangarloo et al., 2000; Franken et al., 1997; Sickles et al., 2002).
6. Residents (junior doctors) covering night shifts in academic hospitals can use teleradiological services to ensure correct diagnosis and to seek confirmation.
7. The increasing disparity in the patient-to-radiologist ratio, especially during off-peak hours, can be effectively addressed by off-shoring teleradiology services.

The increasing availability of technologies that replace invasive screening procedures (virtual colonoscopy replacing actual colonoscopy) means enormous increases in patient volume. Further, defensive medicine increasingly employs tests to guard against missing even the most unlikely diagnosis. The use of head CT in the ED under circumstances when the chance of an abnormal reading is extremely small is one example. It remains commonplace to get a head CT done if the patient has expected meningitis before doing a lumbar puncture, even though the literature indicates this is typically unnecessary. While this example of defensive medicine is not gratifying to mention, it represents the current reality. It also provides another reason why the workload in the radiology department has increased and will continue to increase further.

Teleradiology providers must conform to the guidelines of the Health Insurance Portability &

Accountability Act (HIPAA), and are required to implement adequate privacy and security practices, as Protected Health Information (PHI) and Electronic Protected Health Information (EPHI) are transmitted over public networks on a regular basis. HIPAA requires that "covered entities execute contracts that consist of specific provisions for protection, use and disclosure of health information" (Hilger, 2004). The Privacy Rule deals with all forms of patients' protected health information, whether electronic, written, or oral, while the security rule covers only protected health information that is in electronic form, including EPHI that is created, received, maintained, or transmitted. The security rule does not prescribe any specific technologies; being technology neutral, it allows the HIPAA-covered entities to choose solutions based on their specific requirements. Technical safeguard standards include stringent guidelines for Access Control, Audit Controls, Data Integrity, Person or Entity Authentication, and Transmission Security.

The biggest hurdle to the rapid deployment of teleradiology services is the credentialing process. The U.S. requires statewide licensing requirements and board certifications; as such, a teleradiologist based in Australia must be registered to practice in all the relevant states in the U.S., so to look at radiological images from hospitals in these states, as well as pay appropriate fees to these states on an annual basis. Canada does certification at the national level for radiologists. And in Europe, some of the members of the European Union allow still greater flexibility. The current U.S. regulatory and credentialing structure was designed for a physical presence of medical professionals and needs to be adapted for the evolving technologies and procedures. Recently, some states have modified credentialing laws to allow out-of-state radiologists to perform remote diagnosis. Further, several federal and military healthcare organizations in the U.S. have licensure laws that enable them to render services independent of state and national boundaries. However, such privileges have not been extended to the private sector.

Other obstacles to the growth of teleradiology are:

1. limited availability of reliable Internet connections, especially in remote locations;
2. limited availability of trained technicians;
3. traditional billing and reimbursement procedures that vary by country and state, such as Medicare not paying for services rendered from abroad;
4. variations by nations and states, as well as underlying ambiguity, in medical malpractice liability laws (Gantt, 1999); and
5. the need for incorporating new encryption methods while transmitting image data (Cao, Huang, & Zhou, 2003).

Other related aspects of radiology have been discussed by several researchers (Bradley, 2004; Graschew, Roelofs, Rakowsky, & Schlag, 2006; Hayward & Mitchell, 2000; Jacobson & Selvin, 2000; Kalyanpur, Weinberg, Neklesa, Brink, & Forman, 2003; Kalyanpur, Neklesa, Pham, Forman, & Brink, 2004; Levy & Yu, 2006; Maitino et al., 2003; Mun, Tohme, Platenbery, & Choi, 2005; Takahashi, 2006; Weinger & Ancoli-Israel, 2002).

Over time, the concept of using both onshore and offshore radiologists will grow in terms of overall numbers of radiological images analyzed, as well as in terms of the breadth of the cases studied. Further, we expect the trends in both insourcing and outsourcing to continue. Parts of some medical diagnostic and allied applications will be performed abroad because of lower costs, quicker response, and load balancing. Conversely, more patients from abroad will seek professional advice from medical experts in the U.S. Overall, it appears appropriate to gradually lift barriers that currently impede outsourcing and insourcing activities; most of these barriers are in the former category.

MONITORING AND ENHANCEMENT OF SAFETY

Timely information on adverse drug effects can save lives and reduce healthcare costs. Previous studies show that more than two million adverse drug reactions occur yearly and are responsible for an estimated 100,000 deaths (Lazarou, Pomeranz, & Corey, 1998; Gurwitz, Field, Avorn et al., 2000; Fontanarosa, Rennie, & DeAngelis, 2004). Some systems exist for identifying drugs with serious adverse effects, but they have had limited success (Kopec, Kabir, Reinharth, Rothschild, & Castiglione, 2003; Ray & Stein, 2006). Between 1997 and 2005, the MedWatch system in the U.S. identified 15 drugs with toxic side effects, taking an average of 5.9 years for the identification phase and the subsequent drug withdrawal phase. In general, after the introduction of a drug into the market, the process of eliciting and analyzing information from patients is weak, especially when problems arise during extended use of the drug (U.S. Department of Health and Human Services, 1999; Brewer & Colditz, 1999; Okie, 2005). The problem with Vioxx, for example, was only uncovered during controlled clinical trials (Bombardier, Laine, Reicin et al., 2000). And there is still no system, either in existence or under discussion, for addressing this need at a global level.

In order to address these issues, the Institute of Medicine (2006) presented a report on "The Future of Drug Safety" and made the following recommendations:

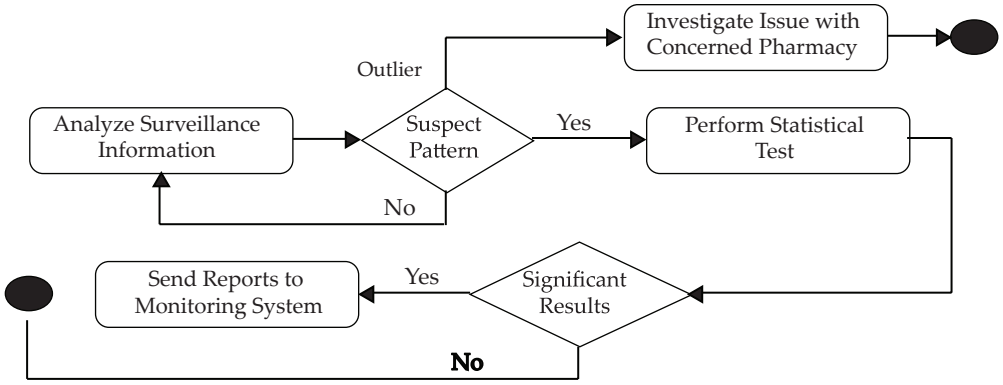
1. increase the FDA's authority to ensure sponsor compliance with standards and regulatory requirements, especially those related to packaging and distribution;
2. establish separate performance goals for safety, in addition to existing goals for speed of approval;
3. ensure proper communication of the drug approval/testing status to consumers and medical practitioners through effective package indicators and advertisements; and
4. improve the facilities, available resources, and organization structure of the FDA.

Towards these goals, a prototype Community Pharmacy Safety Network (CPSN) was developed. Pertinent raw data are spread over the computer systems of multiple organizations including: (1) the one who performed the original drug development work, (2) the one that produced the drug, (3) the one that conducted the clinical trials, (4) the FDA in the U.S. and equivalent government agencies in other countries, and (5) the one that prescribed the medication. In addition, pharmacies contain information on the buyer of the drug, on what date, and in how much quantity. The problems involved in integrating these types of information from diverse sources were discussed in a different context earlier in this article; additional details are available in recent papers by Kalyanpur, Parsia, and Hendler (2005), Corcho and Gomez-Perez (2005), and Cristani and Cuel (2005). The problems become even more complex in the present case because of the need to access information from multiple countries and cultures.

The prototype system, including the key modules, is depicted in Figure 4. Detailed information on the system architecture and allied issues are available in Gupta, Crk, Sarnikar, and Karunakaran (2007a) and Gupta, Woosley, Crk, and Sarnikar (2007c). With proper infrastructure and incentives, pharmacists and pharmacy technicians would be designated agents for collecting raw information on the patient's medication history, including the adverse reactions experienced by the patient.

Development of the prototype system revealed several issues and opportunities. First, some drugs are given as samples by physicians to patients, and significant effort would be involved in incorporating such information into the overall system. Second, individual patients buy drugs from multiple pharmacies; in view of the current guidelines for

Figure 4. Surveillance process for medical drugs (adapted from Gupta et al., 2007a)



privacy of patient records, it is very difficult to link records concerning the same patient from different pharmacies. Third, the procedures differ very significantly across countries. Fourth, analysis of the information requires the use of sophisticated data mining technology, with the help of (human) domain experts and (human) data mining experts. Such experts are already pressed for time in the U.S.; they are expensive too. It therefore seems appropriate to explore if this type of work could be done abroad. For example, one could envisage the creation of a global center of excellence for this particular field in Mexico, close to the U.S. border, so that one could benefit from the less expensive rates in Mexico in conjunction with the feasibility of experts from the U.S. visiting such a center on a frequent basis.

Gopal (2007) and her associates have employed an entirely different approach to assimilate information from patients, especially related to the side effects of alternative medicines. Their approach focuses on the mining of information from chat groups and other online repositories of information voluntarily provided by the patients, such as message boards, blogs, and listservs. They utilize proprietary search and aggregation techniques to distill raw data into structured information that answers critical questions. Their approach, again, utilizes a combination of computer power and human expertise.

DISSEMINATION OF THE LATEST HEALTHCARE INFORMATION

The ideas presented in this section are currently geared more towards medical education and medical research, rather than the provision of improved patient care. The current version of the prototype system enables users to search for current and previous literature, how-to articles, and other educational items. In the future, the enhanced Web site will assist healthcare providers by providing immediate lookups for symptoms and diagnosis. This would not only aid practitioners by giving them access to the latest medication data available, but also reduce treatment times. Further, based in part on a suggestion from a reviewer of this article, access to a human expert will be provided for the purpose of providing additional advice and support on specific cases.

Medical information has been maintained in books, journals, and specialty magazines. Now, a growing number of people turn to the Internet to retrieve healthcare-related information, and they do so from a variety of sources, most of which are run by commercial entities. The next area of growth will be sites that focus on specific fields of medicine, contain data culled from scholarly publications, and are operated by eminent specialists in the field. One such site is

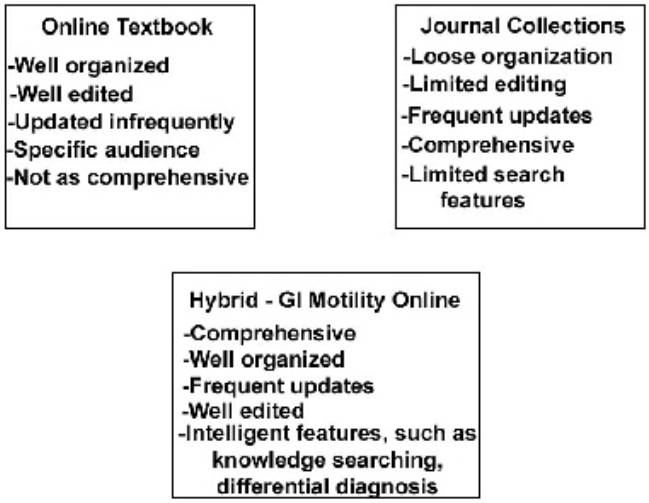
being developed for the field of gastrointestinal motility; it builds upon the concept of existing healthcare information sites with the intention of serving the diverse needs of laypeople, medical students, and experts in the area. The site, called Gastrointestinal Motility Online, leverages the strengths of online textbooks, which have a high degree of organization, in conjunction with the strengths of journal collections, which are more comprehensive, to produce a knowledge base that can be easily updated, is comprehensive, and can provide accurate and high-quality information to users. In addition to implementing existing Web technologies such as Wiki- and Amazon-style commenting options, Gastrointestinal Motility Online uses automatic methods to collect information from various heterogeneous data sources to create coherent, cogent, and current information for the diverse base of users.

Gastrointestinal motility is a very small part of the vast field of medicine. Books such as *Harrison's Principles of Internal Medicine* serve as the main source of information in the field of medicine including gastrointestinal motility (Kasper et al., 2005). Most of these books now also have electronic versions. More recently, electronic texts sites such as Wiki, eMed, WebMD (http://www.webmd.com/), and UpToDate (http://www.uptodate.com/) have evolved and are rapidly gaining popularity. Because these works are designed to provide a broad overview of the field of medicine, they only provide a very superficial treatment to a topic such as gastrointestinal motility. More detailed information about gastrointestinal motility disorders may be found in medical journals. Many journals that were previously in paper format now come out both in paper and electronic formats. Searchable electronic archives, such as PubMed (http://www.pubmedcentral.nih.gov/), now place a plethora of information into the hands of researchers and physicians. However, such searches are very time consuming and inconvenient. Sites like AccessMedicine (http://www.accessmedicine.com/) serve as search engines that attempt to place the most suitable information on a medical topic in a user's hand.

As shown in Figure 5, Gastrointestinal Motility Online is a hybrid between standard textbooks and review articles (Au & Gupta, forthcoming). It seeks to centralize and present the information in a scalable manner that is customized to the user's information requirements. The user base includes: laypersons, patients, medical students, biomedical scientists, physiologists, pathologists, pharmacologists, biomedical students, researchers, pharmaceutical personnel, house staff, specialty fellows, internists, surgeons, and gastroenterologists.

Creation of the gastrointestinal motility knowledge repository started with calls to key gastrointestinal experts inviting them to submit a chapter, in electronic form, for inclusion in this knowledge repository. The titles and themes of these chapters were determined through discussions involving the concerned authors and the editors for this project (Dr. Goyal and Dr. Shaker). The inputs from the contributing authors were reviewed by the editors and by others. Under the aegis of an unrestricted grant from Novartis Corporation, the two editors worked closely with the staff of Nature Publishing Group on a number of tasks that ultimately led to the creation of the Web site, http://gimotilityonline.com. This site may serve as a model for user-driven, scalable, and interactive medical information at a single site for other specific medical topics. These sites can then be interlinked to cover the broad field of medicine. Since GI Motility Online is a hybrid that includes textbook-type material as well as authoritative up-to-date reviews and interactive features, it poses many new problems and opportunities. Currently, all updates must be initiated manually. Automated content generation or extraction from other publications is not feasible, due to the stringent need to maintain relevance and quality. This applies to addition of new material, editing of existing material, and deletion of parts of existing material as new test results become available.

Figure 5. Gastrointestinal motility online is a hybrid of online textbooks and journals.



In the next part of the endeavor, the goal is to enable machine-assisted updating of the material in the gastrointestinal knowledge repository. Given the large number of articles published weekly and the difficulty in ascertaining relevance and quality, a number of automated tools will be used to optimize the updating process. One technique that will assist in the maintenance and updating of the site is presented in Sarnikar, Zhao, and Gupta (2005). This method selects articles ranked by relevance using a combination of both rule-based and content-based methods, using the following principles:

1. Profiles are modeled in the form of rules.
2. The purpose of rule-based profile use is to identify a subset of documents of interest to a user.
3. Each role has a set of predefined rules associated with it.
4. Rules specify knowledge sources to access (for example, nursing journals for nurses).
5. Rules can specify knowledge depth and knowledge breadth.
6. Rules can specify semantic types of primary importance to roles.

Profiles are used in the gastrointestinal motility context to separate information into categories—for example, new clinical findings vs. basic science. Articles could be assigned a category and a weight, given categorization rules based on Unified Medical Language System (UMLS) synonym lists and the categories sign or symptom, diagnostic procedure, therapeutic or preventive procedure, and disease or syndrome semantic types. These tools can form the basis for an RSS XML news feed or to efficiently assemble relevant articles for use by the editors or Web site administrators. While these tools will aid the editor, there is no replacement for the role of humans in selecting and classifying information.

Ontologies and semantic networks are necessary prerequisites to the development of and classification of information repositories. Ontologies serve many purposes including to: reuse and share domain knowledge, establish classification schemes and structure, and make assumptions

explicit. They also allow analysis of information and complement the stricter terminology that is used in straightforward text searches, with or without synonyms. Examples of ontologies in use today include the National Library of Medicine's Medical Subject Heading (MeSH), disease-specific terminologies such as the National Cancer Institute's PDQ vocabulary, drug terminologies such as the National Drug Data File, and medical sociality vocabularies such as the Classification of Nursing Diagnoses and the Current Dental Terminology. In Gastrointestinal Motility Online, the ontological hierarchy will be used to make distinctions between parts of the gastrointestinal tract and the different sections of the stomach and the esophagus (Kumar, 2005).

One of the keys to developing an automated system is the set of ontologies presented in the UMLS semantic network that relies on the concepts built into the UMLS concept hierarchy. An overview of the UMLS is available at http://www.nlm.nih.gov/research/umls/presentations/2004-medinfo_tut.pdf.

THE UNIFIED MEDICAL LANGUAGE SYSTEM: WHAT IS IT AND HOW TO USE IT?

UMLS is an aggregate of more than 134 source vocabularies, including the classifications from such lists as ICD-10 and DSM: IIIR-IV. It represents a hierarchy of medical phrases that can be used to classify articles and textbook entries.

The system described in Sharma (2005) uses techniques of Natural Language Processing (NLP) to construct a semantic understanding that goes beyond text searching. Using the ATIMED (Automated Integration of Text Documents in the Medical Domain) system, the content and order of phrases are related lexically using a concept called Word-Net. Word-Net operates on the verbs, subjects, and objects of the sentences, comparing sets and subsets of subject-verb-object collections in order to determine relatedness to a desired topic. Sharma (2005) uses the following two sentences as examples: Dysphagia is a disease and defined as a sensation of sticking or obstruction of the passage of food. Dysphagia is related to obstruction of passage of food. Since both sentences use similar objects and subjects, and use the verb "is," the sentences would be deemed similar. However, the phrase "Dysphagia relates to obstruction of passage of food" would not result in potential match because the action verb is not similar (Sharma, 2005).

Developing a schema to accurately represent journal abstracts and determine the relevance of those abstracts is one method of exchanging contexts. Innovation in this domain allows Gastrointestinal Motility Online to maintain updated, consistent, quality references without requiring an editor to read all journal articles published immediately. Knowledge-mining tools are being developed to utilize this information as it becomes available to add fast, relevant access and other utility to the information repository. Advanced technologies to aid in the conversion and integration of articles and research into the mainstream science are being integrated and look to impact the breadth and speed of knowledge-base upgrades. These activities involve the use of medical and computer professionals, both in the U.S. and abroad.

The base site is hosted by Nature Publishing Group. As this site was being developed, it was found that commercial tools were available to handle the production of electronic journals and static textbook efforts like AccessMedicine (http://www.accessmedicine.com/) and WebMD. The gastrointestinal knowledge repository falls somewhere in between these two cases; accordingly, few off-the-shelf tools and algorithms were available for immediate use. As such, a significant fraction of the necessary material had to be generated and refined through experimentation.

An interesting addition to the above system is the addition of a "Gastrointestinal Guru," based

in part on a suggestion from one of the reviewers. In specific cases where a person needs access to a human expert, the system will facilitate access to such experts who can provide support on an instantaneous basis. The situation is somewhat similar to the one we experience when we try to make a travel reservation online, experience difficulty, and feel relieved when we are able to connect to a human being, either by phone or online. However, the level of expertise and the degree of structure with respect to the desired knowledge are vastly different in the two cases.

MULTI-PRONGED APPROACH

While the five scenarios discussed above are drawn from different aspects of medical practice, they have several aspects in common. In all cases, the advent of new information technologies is making a major impact on how the particular task or medical specialty is performed (Siau, 2003; Wachter, 2006). Further, in all cases, automation applies only to part of the effort. Human beings still need to be involved, though to varying degrees in the five examples considered. In some cases, a significant part of the work needs to be performed in very close proximity to the patient, whereas in others, the concept of remote tasks can be applied to a large extent. Finally, in some cases, the off-site work is medical in nature, whereas in others it is largely non-medical in character. While similar approaches have been followed in the healthcare industry to some extent in the past, the relevance and practical importance of this model in today's scenarios is more significant. This is happening for several reasons including the following:

- The technology that is available now did not exist earlier. A growing number of previously underserved, remote locations are increasingly able to access medical services through the Internet; and PACS systems are improving rapidly; data and image transfer methodologies are becoming less expensive, more effective, and more error-free. This is resulting in a corresponding need for embarking on international telemedicine endeavors, instead of regional collaborations.
- There is a growing awareness of the advantages of having interoperable health information systems, especially in addressing mass casualty situations, where fast and timely diagnosis, via telemedicine, attains paramount importance.
- The increasing incidence of persons moving across national borders for work or other reasons, as well as the continued trend towards globalization, are making national boundaries lose their traditionally strong importance. As such, one needs the ability to ensure the safety of citizens when they are traveling in foreign countries and taking drugs that were prescribed for them by doctors in the U.S., and to support allied functions. For example, the creation of new global drug efficacy monitoring systems could enable Americans with the same ethnicity or ancestral homeland to be grouped by predictable responses to drugs based on findings by researchers in their native countries.

We consider in the following paragraphs the significance of the diverse examples highlighted throughout this article.

In the case of mammography, a technician needs to attend to the patient in order to take the mammogram; the doctor can be off-site, either in the same country or a different one; and the computer-based data mining algorithms will be executed on an off-site basis too. This is perhaps the earliest example in healthcare where the concept of doing part of the work on-site, part off-site, with the computer providing active decision-support capability, was mooted as the most accurate and the most cost-effective way.

In the case of integration of medical records in heterogeneous systems, either for emergency needs or for routine needs, computer-based techniques can be of significant help, but human experts are needed at the initial stage as well as on a continuing basis. Integration of major systems in other fields, such as logistics and manufacturing, is being increasingly done on an offshoring basis. Banks and financial institutions located in the U.S., Switzerland, and other countries were very reluctant in the eighties and nineties to let such work be performed abroad; by the late nineties, many of them accepted the offshoring concept, after they were satisfied that the evolving security and privacy protocols were adequate for their needs. The same is expected to occur for the integration of heterogeneous hospital information systems; we will consider the legal and regulatory aspects later in this article. In addition to experts in information technology, medical personnel from multiple subspecialties will need to be involved, both on-site and off-site, in order to integrate the concerned systems based on the specific characteristics of the concerned medical institutions.

In the current versions of teleradiology, the technician can be in the U.S. or another developed country, and the radiologist can be in India or another less expensive country; in addition, there is a second radiologist in the same state (or nation) as the patient who issues and signs off on the final report. Technology is used almost entirely for transmitting the image from the developed country to the less expensive one. Over time, technology could be used to partially analyze the images, to compare the image to an earlier one involving the same part of the body of the same patient, and even to compare the image with images of the same part of the body of other patients, in order to make a diagnosis and to evaluate how the symptoms may change over time.

In the case of monitoring for adverse drug effects, the MedWatch system needs to be augmented. Some of the new tasks need to be performed by pharmacists in the U.S. Other tasks, such as reconciliation of duplicate records, need to be performed using inexpensive manpower, wherever available, with support from computer-based techniques. Further, individuals in the U.S. are increasingly obtaining less expensive equivalent drugs from Canada and other countries. Such drugs must also be taken into account while designing any comprehensive system for monitoring adverse drug effects. Ultimately, this system will need to be implemented across multiple systems, as a harbinger of a global system. A growing percentage of clinical trials are now being conducted in India and other countries because of lower costs, availability of drug-naïve persons (individuals who had not taken other drugs in the past for addressing the same disease), and access to persons with different heritages. The ability to conduct these clinical trials at lower costs increases the probability that a drug company would decide to take a potential new drug from the lab to the clinical trial stage. This can also reduce delay in the launch of the new drug. However, this also implies transforming local systems for monitoring adverse drug effects into international ones. In such a case, both medical personnel and other personnel need to work from multiple countries.

In the case of dissemination of healthcare information, the initial endeavor focused on getting reputed experts from multiple countries to contribute material for inclusion in the evolving knowledge repository. The idea was to gradually support automated updates to such material on a continuing basis. So, if new results from a trusted clinical study became available, such results should be incorporated into the appropriate chapters. While part of this work can be done using computer-based techniques, the experience of the development team is that high quality and accuracy will only be accomplished if the suggested edits and updates were reviewed and approved by human experts. The use of domain experts and editorial personnel located in less expensive

countries is more appealing, as it makes the overall endeavor more viable (see Table 1).

While improvements in Internet communication have made the multi-pronged approach described above possible, the lack of standardization in messaging protocols is a roadblock to the creation of a global healthcare model. We now describe how standards can be applied effectively to each of the five operational scenarios discussed, to reduce costs and improve clinical outcomes:

1. In the area of CAD mammography and teleradiology, the communication of radiological images and other data clearly depends on the standards used for creating, maintaining, and exchanging medical images (such as PACS and DICOM).
2. The problem on data exchange and integration from heterogeneous data sources can be solved by the effective use of standards such as HL7. Though the current scenario does not easily allow the adoption of a single data standard among all hospital information systems nationwide, using a standard message development framework as a mediating schema could eliminate some of the problems and make the system more portable and scalable.
3. The area of drug monitoring and post-market surveillance could also benefit from the use of standards. Using standards to create and store medication and adverse effects reports and experimental results sent from various participating agencies would create a much richer database allowing for better analysis and quicker response times.
4. Finally, while considering the issue of dissemination of medical information, the use of standards (not medical standards, though) for storing and displaying the information to the end users can increase the productivity and usefulness of search portals.

24-HOUR KNOWLEDGE FACTORY

Earlier in this article, we discussed the scenario of seeking immediate assistance from an expert in a particular specialty; the geographic location of that specialist was totally irrelevant. The same is true of situations related to some tasks related to mammography and radiology. Finally, in the

Table 1.

Scenario	Tasks by Medical Personnel		Tasks by Non-Medical Personnel		Tasks by Computer-Assisted Techniques
	On-Site	Off-Site	On-Site	Off-Site	
CAD Mammography	X	X			X
Integration of Heterogeneous Healthcare Data Sources	X	X	X	X	X
Teleradiology	X	X			X
Monitoring of Adverse Drug Effects	X	X		X	X
Dissemination of Healthcare Information	X	X		X	X

other two examples of the integration of medical information systems and the creation of global drug monitoring systems, it would be appropriate for the concerned pieces of work to proceed on a continuous basis, around the clock. In all such scenarios, the paradigm of a 24-Hour Knowledge Factory bears relevance.

The University of Arizona has signed a three-party collaborative agreement with the Wroclaw University of Technology in Poland and the University of Technology located in Sydney, Australia. Under the aegis of this agreement, researchers at the University of Arizona can work from 9:00 a.m. to 5:00 p.m., Arizona time. At around 5:00 p.m., Arizona time, the research-in-progress can be transferred to fellow scientists at the University of Technology in Australia, who can work from around 9:00 a.m. to 5:00 p.m., Sydney time. At the end of the "research shift" in Sydney, the professional work can be transferred to the Wroclaw University of Technology in Poland where researchers can conduct incremental activities over the next period of approximately eight hours, and can then transfer the evolving endeavor to the first set of researchers in the U.S. This process is akin to the passing of a baton in a relay race, with the notable difference that the baton is returned back to each participant exactly 16 hours after that participant transfers it to a colleague located on a different continent. We believe that this model will be gradually adopted by the healthcare industry, and further analysis of the historical and structural aspects will determine what subset of healthcare tasks can benefit most from the adoption of this evolving paradigm.

In general, the 24-Hour Knowledge Factory paradigm is appropriate for situations where the healthcare endeavor can be broken down into components, the underlying knowledge can be digitized, different individuals can potentially work on such components with minimal support from their peers, and the work-in-progress can be transferred at minimal cost from one collaborating center to another.

INTELLECTUAL PROPERTY AND LEGAL ISSUES

The performance of medical tasks in a collaborative fashion, on a regular basis, by individuals located across state and national boundaries, raises new issues. Who owns the intellectual property such as patents on new medical or drug inventions? Who can be sued for medical malpractice, and under which set of laws and regulations? How should the charges for medical services be apportioned? What are the corresponding avenues for seeking reimbursements from insurance companies? And what are the mechanisms for seeking redress if and when it becomes necessary? Besides these, there are also other related social and policy-related concerns such as quality control, and assurance and intensity of workflow across boundaries.

In the case of the United States, the FDA plays the dominant role at the national level on issues related to drugs. However, medical professional credentialing and registration are done almost entirely at the state level. As mentioned in the section on radiology, the radiologist can render an initial opinion from outside the particular state or country, but the final opinion is still issued by another radiologist who resides within the particular state and is licensed to practice there. The use of two radiologists, though providing quicker action, increases overall costs.

In the case of patents and intellectual property, there is a common feeling among patent holders around the world that others are exploiting your work. In the U.S., there is a feeling that companies in foreign countries are exploiting U.S. inventions and patents without authorization and payment of royalties. On the other side, there are people in India and China that feel the same way; there are instances of patents issued by the U.S. patent office on items of indigenous nature that have existed for thousands of years. This is somewhat akin to the situation where different states in the U.S.

would render conflicting decisions on the same case, creating confusion. For example, until the 1970s, child custody cases were handled entirely at the state level. So in a case of divorce involving two parents residing in two different states, the first state might well give the custody of the child to the father (who resided in that state), and the second state would likely give custody of the same child to the mother (who resided in the latter state). Finally, in 1992 the Uniform Interstate Family Support Act (UIFSA) was drafted. According to this act, states have the power to reach beyond their borders for the establishment and enforcement of support orders. A similar type of action is now warranted in the healthcare domain.

Let us analyze the issue based on how laws, regulations, and norms have evolved over history. Three thousand years ago, all rules were at the village level. The village was the basis of the economy. If a person did something undesirable, the person could be ostracized from using the village well. Without water, the person could not survive. Therefore, the person had to plead with his or her peers. This was one of the mechanisms, then prevalent, to enforce conformity with the norms and mores of that era. As time progressed, the size of the geographic unit increased. In England, one saw the advent of the concept of the manor, typically a collection of a dozen villages, that functioned as a unit for economic and security purposes. The manor was replaced by still larger entities in the form of principalities, which were ultimately replaced by nation states. The lawmaking and enforcement evolved too, sometimes with overlapping provisions. For example, a person residing in Tucson today may be governed by up to four sets of regulations, of the City of Tucson, Pima County, the State of Arizona, and the United States of America, respectively. (In some areas, such as intellectual property, there may be a supranational layer as well, that is, the WTO's Trade Related Intellectual Property Agreement, which although not applied directly in the United States affects U.S. intellectual property law). Being governed by laws of the U.S. does not imply having to go to Washington, DC, to seek redress; benches of U.S. federal courts exist in most large and medium-sized cities in the United States.

Similarly, in the case of healthcare, the ultimate solution may be an international regulatory system that maintains offices in large cities around the world. This organization could deal with issues related to performing healthcare work across national boundaries. This could include credentialing, registration, medical malpractice, medical accounting, and reimbursement. Such an international regulatory system could be operated under the aegis of the World Health Organization.

Issues of trade and intellectual property are currently coordinated at the international level by the World Trade Organization (WTO) and the World Intellectual Property Organization, respectively. These organizations could serve as the nucleus for establishing streamlined mechanisms that would enable better coordination of emerging types of practices, in healthcare and in other disciplines, perhaps under the aegis of the WTO's General Agreement on Trade in Services. The Agreement on Trade Related Aspects of Intellectual Property is another mechanism of IP protection. Healthcare services will increasingly transcend national boundaries as efforts are made to perform them with speed, efficiency, and in the most cost-effective manner.

CONCLUSION

The traditional model of healthcare required medical personnel to be in immediate proximity to patients being attended to. This model will gradually be replaced, for a growing number of healthcare applications, into a three-faceted model that requires: some personnel to be on-site, other personnel to be off-site, and the use of evolving technologies to render support in a manner that is beyond the capabilities of the best medical personnel available anywhere in the

world. Computers can look at millions of images of mammograms in very short periods of time to locate ones that match the key characteristics of the one currently in the clinic; such power is clearly beyond the capability of a single doctor or even groups of doctors. Off-site personnel can be located in the same state (such as physicians and surgeons of the Arizona Telemedicine program assisting doctors in clinics in Navajo Nation and in other Native American nations), in a different state or a different country. If the support is being provided from a different country, it could be in the same time zone (to provide good overlap) or in a different time zone (to provide complementary advice, especially advice from specialists, during the night in the patient's country). The time difference was initially perceived to be a hindrance; today, it is considered an asset, as it enables better usage of medical and other personnel in both countries. Initially, outsourcing will be embraced using the notion of two collaborating groups that are 10-12 hours apart in terms of time. Gradually, the model of three collaborating centers will be embraced. The use of this 24-Hour Knowledge Factory paradigm allows three centers located in three countries to continue work on a round-the-clock basis, with all the tasks being performed primarily during the day in the respective countries. New international systems must evolve to address the intellectual property, legal, accounting, and other issues related to the various forms of outsourcing.

Medicine is geared to assist mankind as a whole. The offshoring of medical services will benefit developed countries because it can lower overall costs, provide quicker response, and facilitate load balancing. Such offshoring will be advantageous to developing nations because it can widen the range of available medical expertise and enhance the knowledge of healthcare professionals in developing countries. At the same time, one must be conscious of the fact that there is a shortage of medical professionals both in developed and developing countries, and the diversion of such resources to address the needs of foreign patients can potentially aggravate the shortage in their respective home countries. These issues will be partially resolved by market forces. Over time, we will witness more cooperative endeavors involving on-site and off-site activities in the healthcare arena.

ACKNOWLEDGMENT

The authors acknowledge, with sincere thanks, valuable information, comments, suggestions, and assistance provided by many persons, including Shiu-chung Au, Harvey Meislin, Elizabeth Krupinski, Kurt Denninghoff, Rick McNeely, Richard Martin, Surendra Sarnikar, Yan An, Shawna Sando, David Branson Smith, Kit Cheong, Georgina Apresa, and Zak Campbell. Their insights have contributed to enhance the breadth and depth of this article.

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This work was previously published in the Information Resources Management Journal, Vol. 21, Issue 1, edited by M. Khosrow-Pour, pp. 1-26, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 3
Evolving Relationship between Law, Offshoring of Professional Services, Intellectual Property, and International Organizations

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ABSTRACT

This article covers four issues. First, it examines evolving international conventions to determine whether countries, especially developed countries, can take any steps to inhibit offshoring with the objective of protecting jobs in their respective countries. Second, it looks at statistics from independent sources to see if outsourcing exceeds insourcing, or vice versa, in the case of the U.S. Third, it looks at trends in outsourcing in the legal arena. Fourth, it looks at the intellectual property aspects of outsourcing and presents a long-term vision on how this ticklish issue is likely to be addressed in the long-term.

INTRODUCTION

"Outsourcing" is a relatively new term for something that has been happening in the United States for at least 40 years, namely, the shifting of production of goods (and, more recently, services) to nations where wages are lower than in the United States. The most obvious example is textiles and apparel, in which factories located in New England moved to the southeast beginning shortly after World War II, in search of lower-wage, non-unionized labor and low cost electric power. Beginning in the 1960s or earlier, some producers and consumers shifted their sourcing to Asia and to Latin America, particularly to Mexico, Japan, and later South Korea, Taiwan, and Hong Kong. More recently, China, Pakistan, India, Bangladesh, Sri Lanka, and Vietnam have become popular locations, among others, for textile and apparel production.

The outsourcing of service industry jobs from the United States (and Canada, the EU, and Japan, among others) is somewhat more recent, as it is only viable with very low-priced telephone and Internet communications worldwide, a feature of the fiber optic cable construction in the 1990s. Shifting of low-wage telephone service positions (for computer technical support, airline reservations, etc.) did not seem to raise a good deal of controversy in the United States, except perhaps in the communities which lost the service centers (including Tucson), and among the labor unions. Even the outsourcing, particularly from Silicon Valley, of routine computer software work seemingly raised relatively few alarms.

However, the newest outsourcing phenomenon—mostly to India—is far more troubling both economically and politically to U.S. policymakers. The prospect of widespread outsourcing of relatively high wage professional services positions—software development, banking and brokerage, medical, and legal services—is creating a good deal of concern, and there have been various proposals to curb such trends, by legislation or otherwise.

The first question this article addresses is what the United States can do under international trading rules to discourage outsourcing. There may be some tax laws and policies that could be modified, primarily to reduce tax incentives for production abroad and to encourage the investments supporting outsourcing to stay home. Some in Congress have suggested trying to prevent U.S. firms from investing abroad, but in most cases this would be questionable under investment treaties in the unlikely event the Congress tried to impose such restrictions, and would in any event be impossible to enforce against multinational enterprises. There is relatively little action the U.S. could take to reduce the outsourcing process that would not run afoul of international trading rules, which are designed first of all to make it possible for any consumer of goods or services to purchase the best available at the lowest prices, without interference from tariff or non-tariff barriers.

The second question this article addresses is whether the United States is a net beneficiary or net loser when outsourcing occurs. This analysis has been done by others at various levels: at the national level, at the company level, and at the individual level. Companies adopt outsourcing practices because they of lower costs and other benefits. At an individual level, if a person loses a job, he or she is a loser. However, at the national level, the analysis needs more careful attention: outsourcing leads to jobs moving from the U.S. to other countries, and jobs moving from other countries to the U.S.

The third question this article addresses is how outsourcing will impact the legal community in the short-run and in the long-run. Specific examples are considered.

The fourth and final question is how intellectual property can be equitably protected in an economy that involves growing levels of offshoring.

OUTSOURCING UNDER INTERNATIONAL TRADING RULES

Virtually any nation that accedes to the World Trade Organization (WTO) agreements is required to take a number of specific steps toward facilitating freer trade. Most of these involve the reduction or elimination of trade barriers and opening of domestic markets and trading opportunities to foreign-owned firms. Acceding members in recent accessions have made such commitments for almost all product sectors and many service sectors as well. Again, for most nations, agreeing to take these steps through an international treaty necessarily requires a variety of modifications to domestic law and the domestic legal system.

Core GATT Principles

Although it is an over-simplification, it is nevertheless helpful to visualize the generalized agreement on trade and tariffs (GATT)—the original 1947 version and the version adopted as part of the "Uruguay Round" negotiations in 1994, primarily as a mechanism for reducing trade barriers and increasing market access. The GATT does not prevent the use of import duties (taxes on imports), but provides a mechanism (used for eight negotiating "rounds" since 1947) for reducing such duties among member nations. One of the more unusual aspects of the GATT/WTO system—virtually unique in the international law arena—is that the WTO provides for binding third party dispute resolution of trade disputes, with sanctions for members that fail to comply with the rulings of the WTO's dispute settlement body (DSB). More than 365 disputes have been referred to the DSB in the first nearly 13 years of the WTO's existence.

Probably the most important GATT/WTO principle is the principle of nondiscrimination, both as among members of the WTO and between foreign and domestic producers of goods and providers of services. The core principles of GATT 1994 are unconditional 'most-favored-nation' (MFN) treatment among members (Art. I), non-discrimination and national treatment (Art. III), and a prohibition against most quantitative restraints (Art. XI**)**. Most trade restrictions, other than tariffs, particularly quantitative restraints and non-tariff barriers, are essentially prohibited, although there are many important exceptions. Of course, the proper implementation of these principles, and the use of the exceptions to restrict imports, has become a very complex and often-controversial process, the subject of numerous disputes among the GATT contracting parties and, now, the WTO member states.

- **MFN treatment**: Under MFN treatment ("NTR" or "normal trade relations" only under United States law), each member country automatically extends the benefits afforded to any other member country to all WTO members:

  With respect to customs duties and charges of any kind imposed on or in connection with importation or exportation or imposed on the international transfer of payments for imports or exports, and with respect to the method of levying such duties and charges. ..any advantage, favor, privilege, or immunity granted by any contracting party to any product originating in or destined for any other country shall be accorded immediately and unconditionally to the like product originating in or destined for the territories of all other contracting parties. (Art. I)

For example, if the United States were to negotiate with Japan a tariff reduction from 10% to 5% on television receivers from Japan, presumably as part of a package in which Japan made other tariff concessions of importance to the United States, under the MFN principle the 5% rate would be

applicable to televisions imported into the United States from other GATT/WTO member nations as well, without those nations having to make any further concessions in return.

- **Tariff bindings:** GATT Article II provides a framework for multilateral negotiations for the reduction of import tariffs and assurance that once tariffs are reduced they will not be raised again in the future. When a member agrees to specific tariff commitments or reductions, either as part of a WTO negotiation or upon accession, they are incorporated in a country-specific schedule or annex, which is part of the legal agreement. Bound duties average about 3-5% for developed countries like the U.S. and Japan, but may exceed 30% for some poorer countries. Even among developed nations, some duties are much higher; U.S. duties on some apparel are in excess of 20%, and on some "plastic" footwear, over 70%. Once tariffs are reduced and "bound" at a given level, they normally cannot be increased, although there are certain exceptions.
- **National treatment and non-discrimination:** The national treatment and nondiscrimination principles embodied in Article III are designed to assure that imported goods are treated in the same manner as domestic goods, particularly with regard to a country's internal taxation and regulation:

  The products of the territory of any contracting party imported into the territory of any other contracting party shall not be subject, directly or indirectly, to internal taxes or other internal charges of any kind in excess of those applied, directly or indirectly, to like domestic products. Moreover, no contracting party shall otherwise apply internal taxes or other internal charges to imported or domestic products in a manner contrary to the principles set forth in paragraph 1 [so as to avoid protection for domestic production].

  The products of the territory of any contracting party imported into the territory of any other contracting party shall be accorded treatment no less favorable than that accorded to like products of national origin in respect of all laws, regulations, and requirements affecting their internal sale, offering for sale, purchase, transportation, distribution, or use…

For example, if the United States imposes a 5% excise tax on imported petroleum, it must impose the same tax on domestically produced petroleum. The GATT/WTO is designed to reduce tariffs and non-tariff barriers, recognizing that tariff reductions become ineffective if they are merely replaced with quantitative restrictions or other non-tariff barriers.

- **Ban on quantitative restrictions:** In most instances, quotas, embargoes, and other quantitative restraints are prohibited. Even where quantitative restrictions may otherwise be permitted, they must be applied on a non-discriminatory basis under Articles XI and XIII:

  No prohibitions or restrictions other than duties, taxes, or other charges, whether made effective through quotas, import or export licences or other measures, shall be instituted or maintained by any contracting party on the importation of any product of the territory of any other contracting party or on the exportation or sale for export of any product destined for the territory of any other contracting party.

This means that quotas (whether applicable to imports or exports) are prohibited unless they are authorized by a specified exception to Article

XI, as with safeguards measures under GATT Article XIX.

GATT Exceptions

There are, of course, many exceptions to these principles in GATT 1994. The most important include articles VI and XVI (antidumping and countervailing duties), XII and XVIII (balance of payments) XIX (emergency action), XII (restrictions to safeguard the balance of payments), XX (general exceptions), XXI (national security), and XXIV (free trade areas and customs unions). These exceptions reflect recognition that in certain hopefully limited circumstances nations must preserve the right to depart from the principle of nondiscrimination against foreign goods. However, even where departures are permitted, they are narrowly drawn and have been interpreted narrowly by GATT and WTO panels.

- **Balance of payments:** Article XII provides that "Notwithstanding the provisions of paragraph 1 of Article XI, any contracting party, in order to safeguard its external financial position and its balance of payments, may restrict the quantity or value of merchandise permitted to be imported, subject to the provisions of the following paragraphs of this Article." This provision recognizes that under some emergency situations—where, for example, a country's foreign exchange reserves become dangerously low—special consideration in the form of temporary exceptions to tariff level obligations must be recognized. However, Article XII has been interpreted narrowly to prevent abuses. Article XVIII: 2 provides developing countries with greater leeway in protecting their balance of payments.
- **Developing nations:** The GATT itself provides only limited "special and differential" treatment for developing nations. Under the WTO agreements, special treatment is provided with regard to subsidies, intellectual property rights, investment, and safeguards, among others. In most instances, developing countries were given additional time to comply with the specific obligations of the WTO agreements, or are exempted from trade remedy proceedings if the volume of their exports of the affected product to the importing state are small. For example, India and other least developed countries were given 10 years from 1995 to comply with the requirements of the agreement on trade-related intellectual property (TRIPs).
- **General exceptions:** Other so-called "general exceptions" to the core GATT applications are provided, in Article XX:

  Subject to the requirement that such measures are not applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade, nothing in this Agreement shall be construed to prevent the adoption or enforcement by any contracting party of measures:

  a. necessary to protect public morals;
  b. necessary to protect human, animal or plant life or health;
  c. relating to the importations or exportations of gold or silver;
  d. necessary to secure compliance with laws or regulations which are not inconsistent with the provisions of this Agreement, including those relating to customs enforcement, the enforcement of monopolies operated under paragraph 4 of Article II and Article XVII, the protection of patents, trade marks and copyrights, and the prevention of deceptive practices;
  e. relating to the products of prison labor;
  j. mposed for the protection of national treasures of artistic, historic or archaeological value;

g. relating to the conservation of exhaustible natural resources if such measures are made effective in conjunction with restrictions on domestic production or consumption;

h. undertaken in pursuance of obligations under any intergovernmental commodity agreement which conforms to criteria submitted to the CONTRACTING PARTIES and not disapproved by them or which is itself so submitted and not so disapproved.

These provisions permit a GATT member to deviate from certain GATT obligations under the circumstances listed but only consistently with the "Chapeau" requiring that the exceptions not be "applied in a manner which would constitute a means of arbitrary or unjustifiable discrimination between countries where the same conditions prevail, or a disguised restriction on international trade . . . ." For example, on occasion the United States has barred the importation of certain products from China, because it was demonstrated that they had been made with prison labor. The WTO's Appellate Body has interpreted Article XX exceptions narrowly.

- **National security:** There is also an exception for certain actions taken by GATT members on the grounds of national security (Art. XXI). These include preserving confidential information; "taking any action which it considers necessary for the protection of its essential security interests;" actions relating to nuclear materials; measures relating to the prevention of "traffic in arms, ammunition and implements of war...;" actions "taken in time of war or other emergency in international relations; and those relating to compliance with obligations under the U.N. Charter." These exceptions have been used rarely.

GATT also provides an exception from MFN and the non-discrimination principle for free trade areas such as NAFTA and AFTA and China-AFTA, and customs unions such as Mercosur and the European Union (Art. XXIV) (a free trade agreement liberalizes trade among its members, but leaves its members free to set their own tariffs on trade with the rest of the world. A customs union not only liberalizes intra-regional trade, but provides for a common external tariff on members' trade with the rest of the world). Under Article XXIV, only FTAs and customs unions that meet GATT Article XXIV standards are permitted, but WTO oversight and enforcement of FTAs is weak. There is more lenient treatment of regional trade agreements among developing countries under the 1979 GATT "Enabling Clause," which also permits developed country members to offer non-reciprocal trade benefits, such as those provided under the generalized system of preferences.

Limits on the Use of Subsidies and Other Trade-Restrictive Measures

The WTO agreement on subsidies and countervailing measures ("SCM Agreement") imposes significant limitations on the use by governments of subsidies. It a subsidy as a financial contribution by a government or public body involving (1) a direct transfer of funds, (2) the foregoing of government revenue, (3) the provision of goods or services other than general infrastructure, or (4) payments made to a funding mechanism—including a private body—to undertake actions within (1), (2), or (3), provided in each of the four instances that a benefit is conferred on the recipient company (Art. 1.1; "yellow light" subsidies). In general, a subsidy is not actionable under a member country's countervailing duty laws unless it is "specific," in that it is provided to a specific industry or industry group, rather than generally.

The subsidies agreement explicitly prohibits export subsidies and subsidies conditioned on

use of domestic rather than imported materials (often termed "red light" subsidies), except for the least developed countries (Art. 3). Certain types of otherwise actionable subsidies—research and development grants, regional development programs, and environmental cleanup programs (termed "green light" subsidies)—were for 5 years after 1995 specifically exempt (Art. 8). Regional development subsidies are used by many developing nations to encourage industrialization in regions with high unemployment or limited infrastructure. The WTO exception for such subsidies—when generally available to industries within the disadvantaged regions—protects these nations from countervailing duty actions against such exports. The exemption has not been renewed, but presumably will be continued in some form at the conclusion of the Doha Round negotiations.

The subsidies agreement contemplates two often-parallel means for dealing with illegal subsidies. First, as noted, private parties in a member nation may bring administrative countervailing duty actions under domestic law, resulting in the imposition of offsetting or countervailing duties if all the procedural and legal requirements discussed in detail in this section are met (SCM Agreement, Part V). However, a member government may also seek redress through the WTO dispute settlement body. If the action is against prohibited export subsidies, it is sufficient to show the existence of the subsidy (SCM Agreement, Part II). Where the action is against actionable when it believes that another member's use of subsidies is causing (1) injury to one of its domestic industries, (2) "nullification or impairment" of its rights under the subsidies agreement, or (3) "serious prejudice" to any industry in its territory (Part III, Arts. 5, 6). Should the complaining member prevail, the subsidizing country would have the usual choice of complying with the decision by eliminating the subsidy or accepting trade sanctions.

There are other trade remedies available to WTO Members. Most significantly, the WTO agreement on implementation of Article VI of the GATT 1994 (anti-dumping agreement or "AD agreement") permits members to impose antidumping duties (additional import taxes) on foreign goods that are sold in the export market at "less than fair value" and as a result cause or threaten material injury to a domestic industry. Effectively, the rules punish international price discrimination when the product at issue is sold at a lower ex factory price in the export market than in the home market. The agreement on safeguards ("safeguards agreement") allows the "temporary" re-imposition of customs duties or quantitative restraints when increasing imports are shown to cause or threaten "serious injury" to domestic producers.

The agreement on trade-related investment measures (TRIMS) effectively precludes most types of performance requirements. For example, it is generally illegal for a country to require a local manufacturer to use local parts and materials rather than parts and materials imported from another country, or to provide government benefits conditioned on exporting a certain volume of production.

Applicability to Outsourcing of Goods

How can a nation such as the United States counter the use of imported goods over domestically produced goods? This is very difficult prospect. In most cases, raising tariff above agreed (MFN) levels is prohibited. Tariffs bound under GATT Article II at, say, 4%, cannot be raised to 10%. Quantitative restraints (quotas) as noted cannot normally be imposed. Most other non-tariff barriers, such as bogus health and safety standards, can be challenged in the WTO's dispute settlement body. If excise taxes are assessed on foreign goods, taxes at the same rate must be assessed on domestic goods under GATT Article III.

If foreign goods are dumped—sold at lower adjusted prices in the U.S. than in the exporting

countries—dumping duties can be assessed to offset the difference; this may occur much more, since national administering authorities have broad discretion. The U.S., for example, routinely applies high anti-dumping duties on steel, orange juice, softwood lumber, cement, anti-friction bearings, and other products, including many from China. Imposition of dumping duties has become the remedy of choice for the U.S. and more than 100 other WTO member nations, including China and India, since most other protectionists actions are foreclosed or require compensation (as with safeguards). This is of course one way of discouraging outsourcing, although it tends to be used most often against unrelated foreign producers rather than against U.S. subsidiaries abroad.

If foreign goods are recipients of government subsidies, similar penalty duties may be imposed. Safeguards in theory may be imposed where there is serious injury, usually for no more than 4 years. However, U.S. or other WTO member actions are subject to legal review under WTO procedures, and many such actions are overturned by the dispute settlement body. For example, safeguards have been challenged at the WTO in at least five instances, and in each of these cases, the protection afforded to the domestic industries was ruled illegal.

Should the United States decide to subsidize certain industries in an effect to make production in the United States more attractive financially by reducing manufacturing costs, such subsidies could be subject to challenge by other WTO members as a violation of WTO rules.

Nor, under TRIMS, could the U.S. government require U.S. producers to use domestic parts and components rather than foreign ones. This would be counterproductive anyway, as it would encourage the domestic manufacturer to move its entire production abroad.

Trade in Services

The objective of the general agreement on trade in services ("GATS") is simple: over time, to assure that the basic disciplines that have applied to international trade in non-agricultural products for more than half a century—MFN treatment, national treatment, subsidies, transparency, and so forth—are applied to services, with a minimum of exceptions. GATS provides a series of legal rules governing market access and national treatment restrictions. GATS rules apply to regional and local as well as national governments. Members of the WTO agree through a "positive list" approach to restrict use of market access and national treatment restrictions; obligations under GATS, except as noted, are defined largely by members' individual schedules of commitments.

Services obligations are largely divided into three types:

- **Mode 1:** cross-border services, such as when a Tucson, Arizona, lawyer sends a legal opinion by e-mail or courier to Bombay
- **Mode 2:** consumption abroad, as when an Indian lawyer or engineer travels to the University of Arizona to attend a graduate degree program
- **Mode 3:** commercial presence, as when a U.S. bank opens a branch in Shanghai
- **Mode 4:** presence of a natural person, as when an Australian attorney travels to Vietnam to open up a travel agency

GATS provides coverage of all services other than those afforded in the exercise of governmental authority, national treatment (barring discrimination in favor of domestic suppliers), and most favored nation treatment. However, these obligations, unlike parallel ones in GATT, incorporate important exceptions:

- National treatment commitments are not universal, but are limited by each government to the services specifically designated by that government; this contrasts with the GATT 1994, where national treatment is binding once the goods have entered the national market.

- The degree of market access and national treatment can be limited, for example, by permitting foreign banks to own only 49% of a subsidiary.
- Even MFN treatment was subject to exceptions for up to 10 years, with an initial review of the exceptions after 5 years, or beginning in 2000.

GATS also has other important provisions: transparency; reasonable regulations subject to judicial review; absence or restrictions on international payments for services may not be restricted except for balance of payments difficulties; built in schedule for further negotiations.

- **Financial services**: By December 1997, GATS members were able to agree on a broader and much improved series of financial services commitments, totaling 56 schedules representing 70 member governments. A total of 104 GATS members made commitments under the Fifth Protocol. Nations representing over 95% of trade in financial services participated in the agreement. Specific commitments for banks, securities firms, and insurance firms incorporate dozens of pages. However, in general they include: fewer regulatory requirements for foreign commercial presence; "Grand fathering" existing operations that are currently majority owned, even if subsequent limitations have been tightened; broad coverage of insurance, reinsurance, brokerage, agency services, actuarial services, and all banking and stock brokerage functions.
- **Telecommunications services:** Telecommunications is another key services sector where negotiations could not be completed in 1994. Negotiations continued until February 1997, at which time 69 governments made market-opening commitments as part of the "Fourth Protocol" to the GATS or Basic Telecommunications Agreement. More than 95% of the global telecommunications market was covered. While commitments in the sector are generally offered on an MFN basis, several countries took MFN reservations (e.g., U.S., one-way satellite transmission; Brazil, distribution of radio/TV programming to consumers; Turkey, transit land connections and satellite ground station use by neighboring countries; Bangladesh, Pakistan, India, Sri Lanka, Turkey, application of differential measures by governments in setting rates; Antigua, Barbuda, national treatment only for other CARICOM members, etc.).

The coverage of GATS, unlike GATT rules relating to trade in goods, is still incomplete, and is under further negotiation in the now-stalled "Doha Development Round" of WTO negotiations taking place in Geneva from November 2001 to mid-2006, and sporadically thereafter. The focus of these negotiations, like those relating to telecommunications and financial services earlier, has been to eliminate market access restrictions, not to create such restrictions.

Among the other gaps is very limited coverage of subsidies of services activities. GATS contemplates provisions for emergency safeguards and to restrict subsidies of services providers by host governments, but they were to be negotiated after 1995, and those negotiations have not yet succeeded. A provision exists to guard against balance of payments problems, but it has seldom if ever been used, in part because U.S. services providers are the ones which are effectively importing the benefits of the services into the United States.

Implications of GATS for Services Outsourcing

The implementation of GATS has effectively made it easier for developed members such as the United States to outsource services jobs, since it becomes very easy, for example, for a United States firm to open a subsidiary abroad to provide

brokerage back office services (often, perhaps most frequently, the U.S. firm contracts with the service provider in India or elsewhere, rather than owning and controlling the foreign operation). Market access provided by India and other countries in the GATS schedules or in through national legislation fostering foreign investment and business activity generally has also been a significant driving force for outsourcing in the last decade or so. Also, the GATS contains no effective provisions on dumping or subsidization of services. Moreover, the "product" resulting from a foreign service provider—answering your telephone query about a Microsoft computer program or receiving electronically the draft of a legal document or code for a software program—is generally not subject to any kind of effective border controls or other restriction in the importing country.

The entire thrust of the development of freer trade worldwide in goods (since 1947) and in services (since 1995) has been to remove restrictions that would otherwise prevent market forces for determining sourcing decisions. The members of the GATT/WTO have achieved a high level of success in this endeavor, even though many trade restrictions and unfinished business remain. Thus, efforts to restrict such trade in the name of outsourcing are likely to violate binding WTO obligations. Should the U.S. Congress enact WTO — illegal restrictions on outsourcing or imports from certain nations (e.g., India or China) based on exchange rates, they would likely be declared illegal by the WTO's dispute settlement body within a relatively short period of time. Probably the only solution for U.S. outsourcing is for the government to maintain a favorable investment climate and a climate for sophisticated basic and applied research, and tax policies that encourage innovation and investment in technologies that increase productivity and competitiveness, so that outsourced manufacturing or services jobs can be replaced by other jobs requiring special technical skills and knowledge, as has in fact happened repeatedly in the United States since World War II.

Strategy Adopted by State Governments and Local Governments in the U.S.

State governments in the U.S. have used massive subsidies in recent years to attract major foreign manufacturing facilities; examples include the deals made by South Carolina and Alabama to attract BMW and Mercedes respectively. There are also examples of situations where the state government has provided a subsidy to new industries or to existing industries as an incentive to get them not to outsource, and some companies leave the state soon after the contractually mandated period is over.

In the area of outsourcing of professional services, the case most cited in literature is that of the conflicting decisions made by successive governors in Indiana. In September 2003, Governor Frank O'Bannon approved a contract of $ 15.2 million in favor of Tata American International Corp., a New York-based subsidiary of Tata Consultancy Services; this was the lowest bid, between $8.1 million to $23.3 million less than other bids. In November 2003, Governor Joe Kernan canceled the bid, not on the basis of any flaw in the execution of the project by the contractor. Additional details of this decision and other noteworthy decisions by state and local governments are presented in (Gupta et al., 2007).

State and local governments have to grapple between two constraints: on one side, they need to procure services at the lowest possible price; and on the other, they want to maintain the highest possible levels of employment. In the Indiana case, the additional cost of retaining jobs in Indiana was calculated to be $162,500 per job; this is the incremental cost that the taxpayer must bear in order to keep the job in the state (Gupta et al., 2007).

The U.S. constitution specifies that the federal government possesses exclusive authority over all matters pertaining to foreign affairs. Accordingly, it is questionable whether state governments possess the authority to bar procurement of services from abroad. So apart from the international conventions delineated in earlier subsections, the ability to influence outsourcing decisions appears to be further limited by the US constitution.

OUTSOURCING VERSUS INSOURCING IN THE UNITED STATES

There is a perception of IT jobs losses due to outsourcing. However, much of the job loses experienced have been due to the downturn of the economy in 2001, the IT bubble bursting and the tech-laden NASDAQ losing three-quarters of its value during the ensuing 3 years, and to productivity increases in the IT industry as elsewhere. That mistake is compounded when current output and employment levels are compared with levels at the frenzied peak of the boom in 2000 rather than with more normal levels from the late 1990s (Griswold, 2004).

Table 1. Job turnover (thousands) (Source: Bureau of Labor Statistics)

Year	Job Gains	Job Losses	Net Change
1993	29,665	27,032	2,633
1994	30,783	27,621	3,162
1995	31,459	29,079	2,380
1996	32,504	30,061	2,443
1997	33,725	30,757	2,968
1998	34,637	31,805	2,832
1999	35,614	32,924	2,690
2000	35,104	33,143	1,961
2001	32,491	35,442	-2,951
2002	31,691	32,047	-356
Total	327,673	309,911	17,762

The job market is like most other markets, a dynamic and fluid environment that operates in a cyclic manner. Jobs are created and lost, similar to other markets where goods and services are bought and sold. U.S. private-sector employment rose by 17.8 million during the decade from 1993 to 2002. To produce that healthy net increase, a breathtaking total of 327.7 million jobs were added, while 309.9 million jobs were lost. In other words, for every one new net private-sector job created during that period, 18.4 gross job additions had to offset 17.4 gross job losses (Lindsey, 2004). Table 1 provides a visual representation of the trends of job turnover during 1993-2002 to illustrate this point.

Economic analysts and critics might argue that the jobs created are lower paying jobs that replace the more skilled or white-collar jobs that are being lost, and presumably sent abroad. However, management and professional specialty jobs have grown rapidly during the recent era of globalization. Between 1983 and 2002, the total number of such positions climbed from 23.6 million to 42.5 million—an 80% increase. In other words, these challenging, high-paying positions have jumped from 23.4% of total employment to 31.1%. Such high-quality jobs are likely to continue growing in the years to come. According to projections for years 2002–2012 prepared by the Bureau of Labor Statistics, management, business, financial, and professional positions will grow from 43.2 million to 52.0 million—a 20% increase that will lift these jobs from 30% of total employment to 31.5% (Lindsey, 2004).

As the U.S. economy continues its shift to one that is more focused on performing services than on manufacturing, there is a concern that the U.S. is falling behind in this arena. This feeling is partially due to a shift of some high profile service positions, customer service representatives, and telemarketing sales, being sent offshore. Yet the fact is that the United States runs a trade surplus in the IT services most directly affected by offshoring. In the categories of "computer and data

processing services" and "data base and other information services," U.S. exports rose from $2.4 billion in 1995 to $5.4 billion in 2002, while imports increased from $0.3 billion to $1.2 billion over the same period. Thus, the U.S. trade surplus in these services has expanded from $2.1billion to $4.2 billion (Lindsey, 2004).

OUTSOURCING OF LEGAL TASKS ACROSS NATIONAL BORDERS

Technology has progressed to the stage that corporations can select providers of legal services in other countries, even other continents, who offer greater value and faster turnaround times. In some cases, they possess superior domain knowledge too. Limits do exist, however, mostly through state bar associations, which regulate the practice of law to members of the bar. To the extent outsourced services are made the responsibility of a member of the bar, for example, an Indian-American who is a member of the New York Bar and is responsible for supervising paralegals working in Mumbai, the state restrictions are likely not controlling. Issues of client confidentiality and protecting the lawyer-client privilege also arise. Further expansion of legal outsourcing will depend, inter alia, on maintaining a significant cost differential between the United States and Indian salaries for legal support professionals, and availability of such professionals for expansion.

Case Examples of Outsourcing of Legal Activities

The first law firm to expand overseas was Dallas based Bickel & Brewer (Brook, 2005). They opened an office in Hyderabad, India. The founders explained initially this was a solution to "handling the millions of pieces of information that confront us in each case" (Brook, 2005). This office has since spun off to a separate entity (Imaging & Abstract International) that handles work for Bickel and Brewer in addition to several other American clients.

While some American companies are reluctant to have their legal work performed by a company that is not located within the United States because of possible negative press (Jain, 2006), other corporations are setting up captive centers, or locating part of their organizations' legal department to locations such as India (Flahardy, 2005), where labor is often 15-20% of what their U.S. counterparts charge (Rowthorn, 2005). The first U.S. corporation to do this was GE Plastics in 2001. GE had their U.S. staff interview and supervise these new employees who were located in Gurgaon, India. These employees were mainly drafting outsourcing agreements and confidentially contracts. In a 2 year period, GE reported saving "nearly $2 million in legal fees that otherwise would have gone to outside counsel" (Flahardy, 2005). This encouraged other corporations to follow G.E.'s lead, triggering the start of the legal outsourcing industry.

DuPont has hired lawyers in the Philippines (Engardio, 2006) to work 24 hours a day (in three shifts), seven days a week, to prepare documents and code potential evidence for upcoming court cases, a process known as first level document review. As the amount of data that needs to be managed increases, so does the incentives for sending work, electronically, to a facility that can rapidly review and catalog this growing mass of information. DuPont is looking to shorten this process from 18 months to 3 months. The expected savings for this document work is 40% to 60%, a savings of $6 million from their annual budget.

When Paris-based Rhodia, a leading producer of specialty chemicals felt pressure to remain competitive, it entered into a 6 year contract with Accenture to transfer the bulk of its law and accounting functions to a service center in Prague, Czech Republic (Stein, 2003). Accenture moved Rhodia's 15 existing systems to Prague, and then began the process of standardizing their

processes. This model, a shared service center, resulted in cost reductions over 35% in less than 2 years (Cooper, 2003).

While most of the work so far has been low level tasks including transcriptions, document conversions, and legal data entry, there is a shift towards higher value services such as patent law being perform by Indian firms (Sandburg, 2005). Recently, an Indian law firm specializing in patent law, Pangea3, received $4 million from private equity firms (Kannan, 2006). This funding reinforces the belief of industry analysts that legal process outsourcing market will increase to $11.5 billion per annum by 2010 (Jain, 2006).

Legal Tasks and Opinions

The law industry, regardless of the type of practice, is composed largely of three components: research, writing, and litigation or negotiation (the vast majority of civil legal actions in the United States—over 90%—never reach the courtroom. They are settled or mediated). Most lawyers are not litigators. Rather, they are engaged in negotiation of complex legal agreements with private parties or government entities, and assisting clients with regulatory requirements or such documents as wills, trusts, corporate charters, contracts, and so forth. Lawyers often have a heavy work load handling the research and writing as well as the negotiation, litigation, and interaction with clients. The negative effects of this hectic work schedule for the employer are worker burnout and fatigue (Waldmeir, 2003). During the trial phase of a case, lawyers often need to adjust their case in response to the day's events. After they leave the courtroom, they conduct many hours of research to file a motion, or in response to a motion filed. Similarly, a time-sensitive negotiation or Securities and Exchange Commission filing may require almost round-the-clock work by dozens of legal professionals. The fatigue such professionals experience has negative effects on their performance. In addition to trial attorneys, mergers, and acquisitions, SEC and patent law and contract law among others require extensive research and revisions, and attorneys and paralegals practicing in those areas experience similar workloads.

The legal tasks required for litigation support bear significant similarity to financial functions: they both share aspects that predispose them to the benefits of outsourcing. Each consists of vast amounts of information, in printed and electronic form, and requires that the data be tagged and indexed for retrieval upon demand. So, if financial functions can be outsourced at lower costs, one should be able to do the same for allied tasks.

Ethics opinions issued in New York and California proclaim lawyers may ethically outsource legal support services overseas to a non-lawyer as long as the lawyer rigorously supervises the non-lawyer, obtains advance client consent to outsourcing, and bills for outsourcing appropriately (New York City Bar, 2006; San Diego County Bar, 2006). Note, however, that patent filing presents a unique set of constraints due to technology export laws. To mitigate this problem, the U.S. Commerce Department grants export waivers for technology, including blanket export waivers. Many multinational companies have blanket export licenses covering all of their operations (Harris, 2005).

Trends in Legal Industry

Unbundling is a new trend in the legal industry; clients can identify services they want law firms to perform and then select different law firms for different services based on considerations of cost or quality. In essence, legal tasks become a set of commodities. When DuPont needed outside help to manage documentary evidence for product liability cases, it determined that this work, although requiring some judgment, was not difficult or too technical in nature. Instead of opting for a vendor that focused on legal services, DuPont opted for a company with more experience in judgment based work, specializing in back office services.

It selected Office Tiger, a large business process outsourcing provider, with the stipulation that the workers assigned by the latter to DuPont cases will work exclusively on DuPont related matters (The Metropolitan Corporate Counsel, 2006).

The decision-making process took nearly 2 years with several factors that needed to be examined. A common concern is U.S. export control laws restricting the amount of information on new technologies that can be sent overseas. This was a concern for DuPont, being a technological-driven company. This caused DuPont to use a U.S. law firm for such projects that could not be done overseas. For projects that could be conducted overseas, DuPont conducted onsite interviews of potential vendors before making their selection. Once security and quality concerns were addressed, DuPont utilized its own staff to personally train the foreign workers.

In the future, such trips like this will not be necessary, as global standards for the legal outsourcing industry are put into place. A particular project in the Philippines was conducted by trained local persons, under the direct supervision of three persons who possessed law degrees from the U.S. and had been admitted to practice law in the U.S. In India, the new Global Legal Professional Certification test has been announced recently, in order to help identify the most talented subset of the nearly 200,000 individuals who graduate with degrees in law each year.

Legal outsourcing is not simply a means to lower legal costs. After Andrew Corporation, a manufacturer of communications equipment, acquired a division of Deltec Telesystems, a New Zealand manufacturer, Andrew Corp. opted to use the local IP firm that Deltec had used for filing patents (Fried, 2004). This IP firm had acquired a solid reputation for filing radio frequency patents in the U.S. and other markets. Andrew Corporation decided to send all of their U.S. radio frequency patent work to this firm, located in New Zealand, based on this reputation. Further, because of the time difference between the U.S. and New Zealand, work can be conducted on a cyclic basis, with drafts from the IP firm being reviewed and sent back by the client before the firm begins work the following day. This decreases the overall time involved in the patent filing process and offers major strategic advantages and the possibility of true 24-hour knowledge factory operations (Gupta et al., 2007; Gupta & Seshasai, 2007) as illustrated by the scenario in the following paragraph.

There are three legal teams: Group A, B, and C; each located 8 hours (in meridian time difference, not travel time) from each other. When Group A is leaving the courtroom, at the close of the business day, Group B is entering its office. In this example, the opposing legal team is trying to get last minute evidence entered into the trial. Group A sends the case information, along with the results they would like their counter argument (motion) to produce. Group B is now responsible for acquiring all the necessary research to produce the desired result. Group B conducts the research, until the end of its working day. At this point, Group C starts its day. Group C is presented with the information from group A and the research that group B has performed. Group C is now charged with compiling this information into a written motion that will be submitted to the court, or an oral argument that Group A will present to the court. After 8 hours have elapsed, group C is now preparing to go home, and group A is now starting its day. Group C now forwards all information to Group A, who is preparing to return to court. Group A receives: (i) Group A's summary of events and the intended results, (ii) Group B's research, and (iii) Group C's written motion and draft oral argument (could be in written form, or as an audio transcript, or both).

Presumably, Group A has had sufficient rest, and was able to utilize the time for other aspects of the case. The results for using this model have been translated into a strategic advantage. Such mode of operations will allow three teams of workers to perform professional work on a round-

the-clock basis (Gupta et al., 2007; Seshasai & Gupta, 2007).

INTELLECTUAL PROPERTY (IP) ISSUES

The performance of tasks in an outsourced or collaborative fashion**,** by individuals located across state and national boundaries, raises new issues. Who owns the intellectual property such as patents on new medical or drug inventions; who can be sued for malpractice and under which set of laws and regulations; how the charges for services should be apportioned; and what are the mechanisms for seeking redress if and when it becomes necessary? Besides these, there are also other related social and policy-related concerns such as quality control of services and intensity of workflow across boundaries.

In the case of patents and intellectual property, there is a common feeling among intellectual property holders around the world that others may find a way to exploit one's patents or other technology, particularly trade secrets that are not subject to patent protection. In the U.S., there is a feeling that some companies in foreign countries are exploiting U.S. inventions and patents without authorization and payment of royalties. On the other side, there are people in other counties that feel the same way; there are also instances of patents issued by the U.S. patent office on items of indigenous nature that have existed for thousands of years.

This section looks at these issues and proposes an approach that can surmount the current problems and hurdles related to intellectual property.

Foundations of Intellectual Property

Intellectual property (IP) rights are the rights given to persons over the creations of their minds. They usually give the creator an exclusive right over the use of his/her creation for a certain period of time (World Trade Organization, 2007b). The key forms of intellectual property are patents, copyrights, trademarks, and trade secrets. In addition, there are variations to the common forms of intellectual property. For the purpose of this article, an example in the category of geographical indicators (GI) is focused on. A GI identifies "a good as originating in a locality where a given quality, reputation, or other characteristic of the good is essentially attributable to its geographic origin" (Field, 2006).

Since intellectual property shares many of the characteristics of real and personal property, associated rights permit intellectual property to be treated as an asset that can be bought, sold, licensed, or even given away at no cost. IP laws enable owners, inventors, and creators to protect their property from unauthorized uses (Field, 2006). On a macro scale, the importance of IP to social and global development is three fold:

- **Convenience:** The most obvious reason is that these creations translate into making some of life's most common and enduring activities more convenient. For example, communication between people became easier when the postal system was created. As time progressed, the telephone was developed, which allowed for direct communication across greater distances. Later, the cellular phone was developed to allow talkers to have direct communication with each other outside of their homes—in fact, anywhere.
- **Economic growth:** The World Bank's Global Economic Prospects Report for 2002 confirmed the growing importance of intellectual property for today's globalized economies, finding that "across the range of income levels, intellectual property rights (IPR) are associated with greater trade and foreign direct investment flows, which in

turn translate into faster rates of economic growth."

- **Innovation:** Effective IP enforcement encourages creation and invention.

The World Intellectual Property Organization estimates that copyright industries alone contributed $791 million, or 7.75%, to the U.S. economy in 2001 (Wayne, 2004). Estimates of U.S. companies' worldwide losses to counterfeiting and piracy range from $200 to $250 billion per year (Wayne, 2004).

Intellectual Property and Role of International Organizations

One of the major governing bodies related to protection of IP on an international basis is the World Trade Organization (WTO). The current policy evolved during the 1986-1994 Uruguay round of multilateral trade negotiations (World Trade Organization, 2007a). The TRIPS (agreement on trade related aspects of intellectual property rights) was an attempt to bring IP rights under the protection of shared international rules governing related trade issues. TRIPS establishes minimum levels of protection that each member has to give to the intellectual property of fellow members. Governments are allowed to reduce any short term costs through various exceptions. For example, this maneuver could be executed in order to tackle public health problems. The agreement covers five broad areas (World Trade Organization, 2007a):

- how basic principles of the trading system and other international intellectual property agreements should be applied
- how to give adequate protection to intellectual property rights
- how countries should enforce those rights adequately in their own territories
- how to settle disputes over intellectual property between members of the WTO now that the provisions of TRIPS apply to all WTO Member states

The second part of the TRIPS agreement looks at different kinds of intellectual property rights and how to protect them. Its main goal is to make certain that member countries have an understanding of its provisions for IP protection. The basis of the TRIPS agreement can be traced back to the late 19th century. More specifically, its basis was founded around the Paris Convention for the Protection of Industrial Property of 1883 (World Intellectual Property Organization, 2007b). Topics that were addressed in this agreement included, but were not limited to, patents, industrial designs, and so forth (World Trade Organization, 2007a). Later, the Berne Convention for the Protection of Literary and Artistic Works in 1886 established international copyright laws (World Intellectual Property Organization, 2007a). Evidently, some areas concerning IP were not discussed—for example, geographical indicators. Or, those protection standards that were discussed were later found to be insufficient.

The WTO evaluated the proceedings of the earlier two conventions, and determined that higher standards were needed today, especially with respect to the enforcement aspect. Part 3 of the TRIPS agreement was written specifically to address this issue. Yet, before going into the weak points of this section, an understanding of what Part 3 attempts to enforce must be made known. According to the WTO:

The agreement says governments have to ensure that intellectual property rights can be enforced under their laws, and that the penalties for infringement are tough enough to deter further violations. The procedures must be fair and equitable, and not unnecessarily complicated or costly. They should not entail unreasonable time-limits or unwarranted delays. People involved should be able to ask a court to review an administrative decision or to appeal a lower court's ruling.

The agreement describes in some detail how enforcement should be handled, including rules for obtaining evidence, provisional measures, injunctions, damages and other penalties. (World Trade Organization, 2007a).

More specifically, a major difficulty that member countries face is how to enforce efficiently what the WTO has set out to be a stringent set of rules. It is thought that this problem stems from the fact that the TRIPS agreement does not require all member countries to have uniform rules on protection of intellectual property. According to the WTO, the TRIPS Agreement only:

... requires members to comply with certain minimum standards for the protection of intellectual property rights covered in it; however, members may choose to implement laws which give more extensive protection than is required in the agreement, so long as the additional protection does not contravene the provisions of the agreement. (World Trade Organization, 2007a)

This implies that member countries need only to adhere to the minimum standards of the agreement.

When the member countries adhere to the minimum requirements of the agreement, they have:

...the freedom to determine the appropriate method of implementing the provisions of the agreement within their own legal system and practice—taking into account the diversity of members' legal frameworks (for instance between common law and civil law traditions). (World Trade Organization, 2007a)

Two issues arise as a result of this line of thought:

While some countries believe heavily in the protection of IP and strict laws to enforce that protection, there are other countries that settle for the bare minimum requirements of TRIPS. Although there is a clear disparity, this is acceptable, and both countries are considered to be in compliance with the requirements of the TRIPS agreement.

Further, the protection of IP outlined by TRIPS remains unstable due to lack of clarity surrounding the legal rules governing market access and national treatment restrictions as outlined in the GATS—which essentially bolsters IP protection. Generally, the wordings of the GATS guidelines are vague and it has rarely been tested in legal disputes; more specifically, members question its:

"…market access rules and subsidies and the unwillingness or incapability of the proponents… to give guarantees that the feared negative consequences can be excluded or ruled out" (Bienefeld, 2003). This could greatly expose any IP being shared and raises the possibility of infringement. In essence, "…is still largely a terra incognita for most trading nations" (Horn & Mavroidis, 2006).

International Property Arguments at International Level

According to Friedman (2005), the 2001 Chinese accession into the WTO was largely based on the goal of destroying internal bureaucracy as it negatively affected international trade and encouraged political and economic corruption. Friedman (2005) suggests that a more "codified law" would aid in the control of such problems. It should be noted that lack of local IP enforcement can definitely cause a lack of support for expanding trade between two countries. Such was the case in 2003 when the U.S. was apprehensive in trading with China; since then, China has strengthened the enforcement of its protection policy (Wayne, 2004), but not to the satisfaction of the United States, which has challenged the failure of China to meet its TRIPS obligations (*China—Measures Affecting the Protection and Enforcement of In-*

tellectual Property Rights (Complainant: United States), DS 232, April 10, 2007).

Consider a specific example from the U.S. according to The New York Times article "U.S. Permits 3 Cancer Drugs from Cuba" (from July 15, 2004 issue) the U.S. federal government allowed biotechnology company CancerVex to license three experimental cancer drugs from Cuba. This was surprising because this allowance was essentially an exception to the highly restrictive trade policy of the U.S. with Cuba. Historically, the U.S. has imposed a series of embargos on Cuba. Most notably, the Cuban Liberty and Democracy Solidarity Act (1996) penalizes foreign companies that have done business in Cuba by preventing them from doing business in the U.S. The European Union vehemently voiced its disdain of this act because it felt the U.S. was dictating how other nations conducted their trade—which was essentially what it was doing—until negotiations were conducted. Such disputes could be better resolved if there was a good mechanism to handle them.

Consider another example. Basmati rice serves as the traditional staple diet of tens of millions of people in South Asia. Based on research conducted on the total export of basmati rice, it was concluded that exports worth $350 million from India and $250 million from Pakistan were at stake at the time of the award of patent (Chandola, 2006). On September 02, 1997, Texas-based company RiceTec was awarded a patent by the U.S. Patent and Trademarks Office in regards to basmati rice. The patent was vague, allowing RiceTec the rights to exclusive use of the term ''basmati," a monopoly on farm-bred Indian/Pakistani basmati varieties with any other varieties in the Western Hemisphere, as well proprietary rights on the seeds and grains from any crosses (Uzma, 1998). The allowance of this patent caused uproar among the concerned parties of the South Asian subcontinent, as they feared bio-piracy by the West (Vandana, 2001). There were three main issues that concerned this patent:

a theft of collective intellectual and biodiversity heritage of Indian farmers; a theft from Indian traders and exporters, whose markets are being stolen by RiceTec Inc.; and finally, deception of consumers since RiceTec is using a stolen name, basmati, for rice that is derived from a variation of Indian rice but not grown in India, and hence of a different quality. (Ray, 1998)

India's concerns, in fact, were supported by international law and RiceTec was not given new rights or any right given to market their varieties as equivalent to or superior to basmati (Chandola, 2006). According to the TRIPS agreement itself, Article 22 defines a GI as:

...indications which identify a good as originating in the territory of a member, or a region or locality in that territory, where a given quality, reputation or other characteristic of the good is essentially attributable to its geographical origin.

Basically, in order to be protected, the GI is not required to have the same name of a geographical place, but must be an indication of that place. In this case, "basmati" is taken to be an indication of rice coming from the Indian subcontinent.

Interestingly enough, RiceTec had been selling and marketing basmati rice by the brand Texamati and Kasmati for over 20 years in 30,000 stores in North America (Chandola, 2006). So why did India not challenge the registration of this brand in the USA? Article 24.5 of the TRIPS agreement provides that:

...where a trademark identical or similar to a GI has been applied for or registered or used in good faith before the application of these provisions of TRIPS in the member state or before the protection of the geographical indication in the country of

origin, such a registration is valid and cannot be challenged. ("TRIPS")

Based on this proviso, India could have challenged both the trademarks because the violated the provision of "good faith." The problem, however, is that India, would have had to challenge the dispute in American courts. Historically, American courts have in some instances appeared to favor their national companies and this is a serious disadvantage to an overseas defendant [see Mother's Restaurants v. Mother's Other Kitchen, Inc. 218 U.S.P.Q. 1046 (TTAB1983); Person's Co., Ltd. V. Christman 900 F.2d 1565 (Fed. Cir. 1990), 14 U.S.P.Q 2d, 1477 for correlating evidence] (Chandola, 2006). However, there are other prominent cases that culminated in a result that favors the foreign party over the U.S. firm. For example, in Bremen v. Zapata Offshore Oil, 407 U.S. 1 (1972), the Supreme Court deferred to a contractual choice of law case and forced an American party to bring its court action in England rather than the U.S. In Mitsubishi v. Soler Chrysler-Plymouth, 473 U.S. 614 (1985), the Supreme Court enforced an arbitration clause against a U.S. auto dealer in favor of the Japanese auto manufacturer. Nevertheless, if the dispute had been tried in India, RiceTec would, most likely, have been held accountable for the infringement, and the costs to the plaintiffs would have been significantly lower too.

The international IP area provides enormous challenges for companies and other holders of IP rights that wish to enforce those rights in national courts. TRIPS provides a basis for government-to-government action where, for example, a local patent office may discriminate against foreign patent holders on a systematic basis, but is not useful for dealing effectively with individual company infringements. Under the best of circumstances, IP litigation in national courts is expensive and time-consuming, with the results often difficult to predict.

Long-Term Solution for Addressing Issues at Global Level

Apart from the problems mentioned, the lack of global consensus on intellectual property issues is increasing the net cost to the customer in unforeseen ways. Consider this example from the healthcare arena. In the U.S., the FDA plays the pivotal role on issues related to drugs. But, each state is responsible for handling all medical professional credentialing and registration issues. The radiologist can render an initial opinion from outside the particular state or country, but the final opinion must usually be signed by another radiologist who resides within the particular state and is licensed to practice there. The use of two radiologists, though providing quicker action, tends to increase overall costs (Gupta et al., 2008).

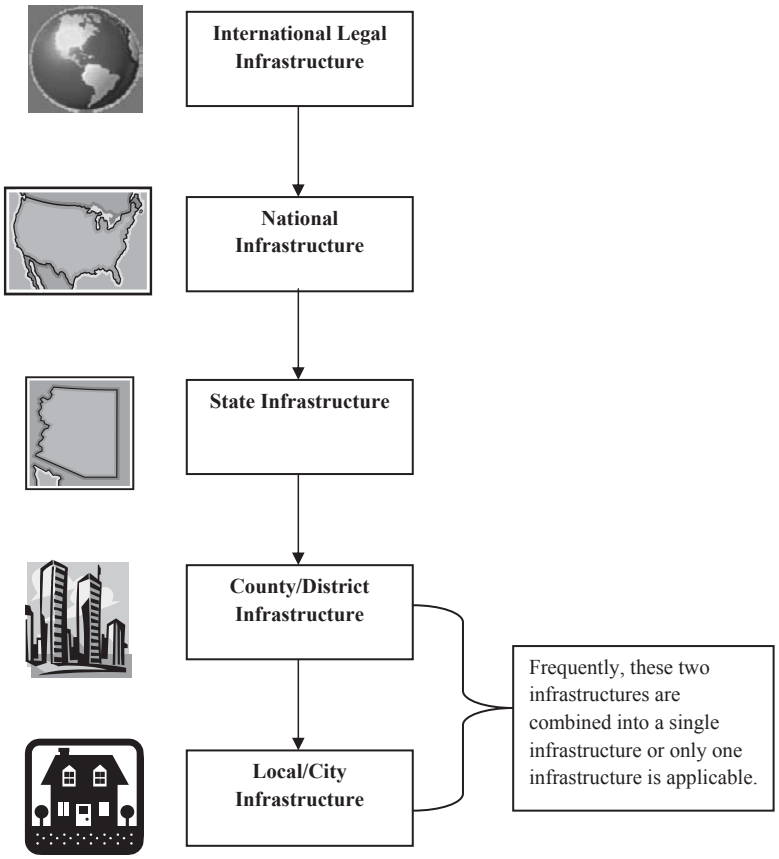
As mentioned earlier in this section, a widespread feeling exists among holders of intellectual property, both in the U.S.and abroad, that others are exploiting their work. Courts in different countries give conflicting judgments, with some evidence of bias in favor of companies domiciled in their respective countries. This is similar to situations where judges in different states in the U.S. would render conflicting decisions on the same case, creating confusion need for reconciling these decisions at the inter-state level; now the issue is at a nation-to-nation level.

Consider a specific situation. Until fairly recently, child custody cases were handled entirely at the state level in the U.S. In divorce cases involving parents residing in two different states, the first state could grant the custody of the child to the mother (who resided in that state), and the second state could grant custody of the same child to the father (who resided in the latter state). In order to mitigate this problem of conflicting judgments, the Uniform Interstate Family Support Act (UIFSA) was drafted in 1992. According to this act, which has now been adopted in all of the U.S., states have been provided with the power to reach beyond their borders for the establishment and enforce-

ment of support orders. A similar type of action is obviously desirable in the arena of intellectual property, at the international, nation-to-nation level, but agreement has proven elusive. Even the members of the European Union, after more than 40 years of trying, have not been able to agree on a uniform patent statute to be applied in the same manner by all member states.

Let us step back from the specific aspect of intellectual property to analyze the broader subject of how laws, regulations, and norms have evolved over history. In 1000 BC, all rules were maintained and enforced at the village level. The village constituted the unit of economy. If a person engaged in inappropriate behavior, he or she could be denied the ability to draw water from the village well. The concerned person then had to plead with his or her peers in order to survive. This was a mechanism to enforce norms and mores of that village-based society. Over time and with the advent of better means of transportation, the legal unit increased in geographic size, first to a collection of a dozen villages, then to principalities, and ultimately to nation states. The lawmaking and enforcement mechanisms evolved too, frequently with overlapping jurisdictions. For example, a person residing in Boston today may be governed by up to five sets of regulations, of the City of Boston, Suffolk County, the State of Massachusetts, and the United States of America, respectively. Being governed by laws of the U.S. does not imply having to go to Washington D.C.

Figure 1.



to seek redress; benches of U.S. federal courts exist in most large and medium-sized cities in the United States.

Why was one layer of legal infrastructure adequate 3000 years ago, but multiple layers of infrastructure (see Figure 1) needed today? The answer lies in the growing sophistication of society and the widening circle of influence for each individual and organization. If one drives too fast, then the legal system at the local level is adequate to address the situation. If one manufactures goods in one state of the U.S. and sells in another state, then the guidelines of interstate commerce, established at the federal level, apply to safeguard the interests of the sellers and the buyers. As global trade becomes more prevalent, new legal mechanisms have to evolve. Such trends are being witnessed. For example, in some areas, such as intellectual property, there may be a supranational layer as well, that is, the WTO's trade related intellectual property agreement, which although not applied directly in the United States, affects U.S. intellectual property law.

In the case of intellectual property, the ultimate solution may be an international regulatory system that maintains offices in large cities around the world. This organization could deal with issues that transcend national boundaries. The organization that performs this role could be a new one or an existing one such as WIPO or the WTO. Further, it is possible that different organizations would be appropriate for different areas of expertise. For example, the agency that could address issues of medical credentialing, registration, malpractice, accounting, and reimbursement could be operated under the aegis of the World Health Organization (WHO).

Issues of intellectual property and trade are currently coordinated at the international level by the World Intellectual Property Organization (WIPO) the World Trade Organization (WTO), respectively. These organizations could serve as the nucleus for establishing streamlined mechanisms that would enable better coordination of emerging types of practices, in various disciplines, perhaps under the aegis of the WTO's general agreement on trade in services. Professional services of diverse types will increasingly transcend national boundaries as efforts are made to perform them with speed, efficiency, and in the most cost-effective manner. The availability of the proposed mechanism for global coordination of intellectual property and allied issues will be of major benefit to large constituencies of individuals and organizations around the world.

In order to convert the idea into reality, a critical mass of countries would need to subscribe to the proposed approach, and to the duties and the responsibilities that are inherent in it. Under current political realities, particularly in the United States and other major trading nations (EU, India, China, Brazil, etc.), broad agreement on such a mechanism seems extremely unlikely in the foreseeable future. Note, however, that it is not necessary for all the countries to agree to the idea; further, it is not necessary that the dominant countries subscribe to the concept at the initial stage. When one of the authors of this article was leading the effort to establish the Internet Telephony Consortium at MIT during the nineties, the strongest opposition came from the largest telecommunications company that existed at that time. The representative of this company raised objections at each stage. Finally, this particular author told the concerned repre¬sentative that his company did not need to join this consortium if it had so many reservations about the concept of the proposed consortium. Immediately, the representative said that if the consortium was formed, his company would definitely be a member of it. Usually, the company or country that is the strongest is the one who resists the consortium approach more than others. Of course, an international/ supranational IP system that did not include the United States, the EU, and Japan would not have much practical utility.

Historically, matters involving multiple countries have evolved at a slow pace. For example,

the law of seas "…developed in the 10th to the beginning of the 11th century where the city-state of Amalfi…had a code of maritime law, which served as the model for laws on the Mediterranean Sea (UN Atlas of the Oceans, 2007)". As time progressed these laws were expanded and redefined to satisfy the desires of the dominant world power of the time. It was not until the early 1980s, during the finalization of the United Nations Convention on the Law of the Sea (also known as UNCLOS III), that a final set of regulations was developed (The Peace Palace Library Centennial Exhibition, 2004), and the United States, the world's largest sea power, has not acceded. There are other examples where matters have progressed very fast.

Note also that despite the predictions of many experts, the European Union did become a reality, and its member governments opted to surrender some of their traditional powers for broader good. Further, even though the United Kingdom, Sweden, and Denmark opted to retain their own currencies, the notion of a common currency was widely accepted. In fact, nations moved from their respective currencies that were centuries old and moved to the euro in an unprecedented short period of time. The notion of countries agreeing to closely cooperate in other parts of the world is exemplified by Mercosur, NAFTA, and other regional trade agreements. So, there are several good precedents where nations have relinquished at least some of their customs, traditions, and procedures rapidly, and have accepted oversight authority that is outside national control.

A more likely-to-be obtainable approach, at least in the short to medium term, would be to expand TRIPS to provide not only minimum standards for protection but uniform standards for the registration of patents, trademarks, copyrights, and so forth, which would then be incorporated into domestic law in all of the WTO member states, and enforced by existing national IP entities. This uniform law approach, which has been used successfully in other areas (e.g., Convention on the International Sale of Goods), raises far fewer "sovereignty" concerns than the designation of an international entity with offices in member countries, and would achieve most of the same objectives. However, as noted earlier, there is resistance to such IP uniformity even within major regional trading groups such as the EU.

Finally, if some countries opt against joining a common approach to coordinate intellectual property enforcement and allied matters, such countries are likely to suffer over time in terms of their level of trade with other countries.

CONCLUSION

Despite the public rhetoric of politicians and others, governments of developed countries can do little to inhibit the global trend towards outsourcing without violating the commitments they have made at the international level. Overall, more jobs come to the U.S. than go out, because of outsourcing. The U.S. is the net beneficiary in terms of net number of jobs and especially in terms of net dollar amounts as the job coming in carries higher remuneration than the job performed abroad. The trend towards outsourcing of legal services, among others, may accelerate over time, assuming adequate supplies of low priced, well-trained professionals in such countries as India. Finally, there is an urgent need to adopt a new mechanism for handling of intellectual property rights and allied issues at the international level, even if the first step is harmonizing national IP laws and procedures through amendments to the TRIPS or WIPO agreements.

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This work was previously published in the Information Resources Management Journal, Vol. 21, Issue 2, edited by M. Khosrow-Pour, pp. 103-126, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 4
Ensuring Correctness, Completeness, and Freshness for Outsourced Tree-Indexed Data

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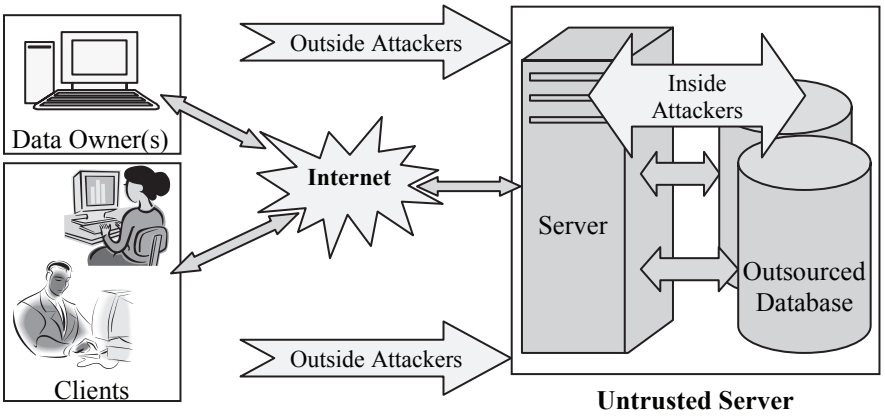
ABSTRACT

In an outsourced database service model, query assurance takes an important role among well-known security issues. To the best of our knowledge, however, none of the existing research work has dealt with ensuring the query assurance for outsourced tree-indexed data. To address this issue, the system must prove authenticity and data integrity, completeness, and freshness guarantees for the result set. These objectives imply that data in the result set is originated from the actual data owner and has not been tampered with; the server did not omit any tuples matching the query conditions; and the result set was generated with respect to the most recent snapshot of the database. In this paper, we propose a vanguard solution to provide query assurance for outsourced tree-indexed data on untrusted servers with high query assurance and at reasonable costs. Experimental results with real datasets confirm the effciency of our approach and theoretical analyses.

INTRODUCTION

Outsourcing database services is emerging as an important new trend thanks to continued growth of the Internet and advances in the networking technology. Organizations outsource their data management needs to an external service provider, thereby freeing them to concentrate on their core business. In this outsourced database service (ODBS) model, organizations rely on the premises of external service providers, which include hardware, software, and manpower, for the storage and retrieval management of their data, and they operate other business applications via the Internet without having to maintain applications *in-house*. Figure 1 depicts key "actors" in

Figure 1. The ODBS model and security threats at the server side



the most general and complicated ODBS model (Mykletun, Narasimha, & Tsudik, 2004),[1] where multiple data owners (say, separate departments of an organization) outsource their data to a certain database server (which may be untrusted) and allow users (may be other departments, partners of the organization, or even themselves) to access the outsourced data. This service model is a recent and important manifestation of the outsourcing trend of different information technology services. As we can see, however, among issues needing to be addressed in order to make this model reality, security-related issues must be of crucial concern due to the fact that the server may be untrusted, and both data as well as users' queries can now be exposed to the server and hackers/malicious users (corresponding to inside and outside attackers as shown in Figure 1, respectively). This means that, in this ODBS model, apart from secure network communication channels and other necessary security procedures at the user side (Axelrod, 2004), efficient and effective solutions to security threats inside the server are indispensable. We discuss in more detail these server-side security-related issues below.

Security Issues in the ODBS Model

Since a service provider is typically not fully trusted, the ODBS model raises numerous interesting research challenges related to security issues. First of all, because the life-blood of every organization is the information stored in its databases, making outsourced data confidential is therefore one of the foremost challenges in this model. In addition, privacy-related concerns must also be taken into account due to their important role in real-world applications.[2] Not less importantly, in order to make the outsourced database service viable and really applicable, the query result must also be proven qualified. This means the system has to provide users with some means to verify the query assurance claims of the service provider. Overall, most crucial security-related research questions in the ODBS model relate to the below issues:

- **Data confidentiality:** Outsiders and the server's operators (database administrator–DBA) cannot see the user's outsourced data contents in any cases (even as the user's queries are performed on the server).
- **User privacy:** Users do not want the server and even the DBA to know about their queries and the results. Ensuring the user privacy is one of the keys to the ODBS model's success.
- **Data privacy:** Users are not allowed to get more information than what they are query-

ing on the server. In many situations, users must pay for what they have got from the server and the data owner does not allow them to get more than what they have paid for, or even users do not want to pay for what they do not need because of the low bandwidth connections, limited memory/storage devices, and so forth. This security objective is not easy to obtain and a cost-efficient solution to this issue is still an open question (Dang, 2006b).

- **Query assurance:** Users are able to verify the correctness (authenticity and data integrity), completeness, and freshness of the result set. Among all security objectives, the query assurance is *always* appealed in the ODBS model. We succinctly explain these concepts as follows, and more discussions can be found in Narasimha and Tsudik (2006), Mykletun et al. (2004), Boneh, Gentry, Lynn, and Shacham (2003), Pang and Tan (2004), Pang, Jain, Ramamritham, and Tan (2005), and Sion (2005):
  - **Proof of correctness:** As a user queries outsourced data, it expects a set of tuples satisfying all query conditions and also needs assurance that data returned from the server originated from the data owner and have not been tampered with either by an outside attacker or by the server itself.
  - **Proof of completeness:** As a user queries outsourced data, completeness implies that the user can verify that the server returned *all* tuples matching all query conditions, that is, the server did not omit any tuples satisfying the query conditions. Note that a server, which is either malicious or lazy, might not execute the query over the entire database and might return no or only partial results. Ensuring the query result completeness aims to detect this unexpected behavior.
  - **Proof of freshness:** The user must be ensured that the result set was generated with respect to the most recent snapshot of the database. This issue must be addressed so as to facilitate *dynamic* outsourced databases, which frequently have updates on their data.

The above security requirements differ from the traditional database security issues (Castano, Fugini, Martella, & Samarati, 1995; Umar, 2004) and will in general influence the performance, usability, and scalability of the ODBS model. Although there exist a number of research works on the above topics (e.g., Du & Atallah, 2000; Hacigümüs, Iyer, Li, & Mehrotra, 2002a; Bouganim & Pucheral, 2002; Damiani, Vimercati, Jajodia, Paraboschi, & Samarati, 2003; Lin & Candan, 2004; Chang & Mitzenmacher, 2004; Dang, 2006a, 2006b), to the best of our knowledge, none of them has dealt with the problem of ensuring *query assurance* for *outsourced tree-indexed data*. It has been clearly proven in the literature that tree-indexed data have played an important role in both traditional and modern database applications (Dang, 2003). Therefore, security issues in query assurance for outsourced tree-indexed data need to be addressed completely in order to materialize the ODBS model. This is even then not a trivial task, especially as tree-based index structures are outsourced to untrusted servers (Du & Atallah, 2000; Dang, 2005). In this article, we will discuss and propose solutions to security issues in order to provide query assurance for *dynamic* outsourced databases that come together with tree-based index structures. Our techniques allow users to operate on their outsourced tree-indexed data on untrusted servers with high query assurance and at reasonable costs. Our proposed solutions will address all three desired security properties of query assurance.

In addition, as presented in Du and Atallah (2000), Mykletun et al. (2004), and Dang (2006b),

there are a number of different ODBS models depending on desired security objectives. In this article, however, due to the complexity of the big problem, we will focus on the most basic and typical ODBS model where only *data confidentiality, user privacy,* and *query assurance* objectives should be taken into account. Our holistic solution allows users (also the data owners in our considered ODBS model) to manipulate their outsourced data as it is being stored in in-house database servers.

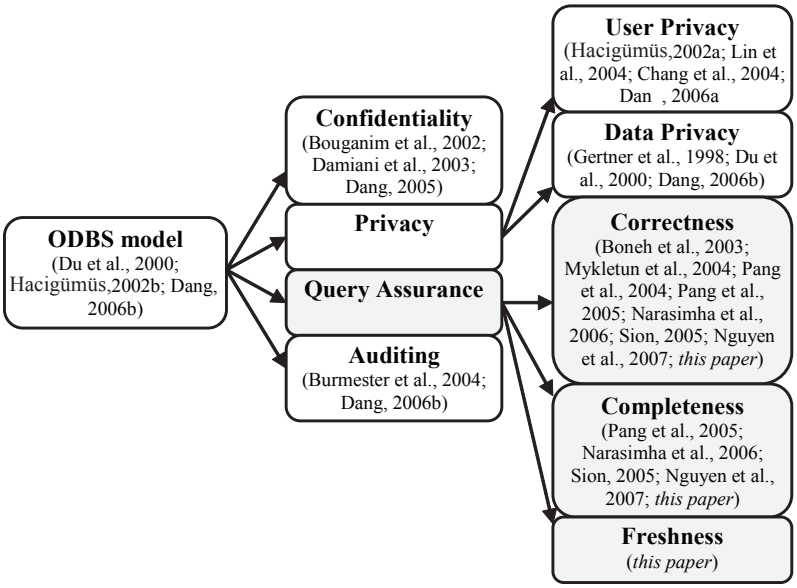
The rest of this article is organized as follows. We briefly summarize main related work and introduce a state-of-the-art approach to managing outsourced tree-indexed data without query assurance considerations. After that, we present our contributions to completely solve the problem of query assurance in dynamic outsourced tree-indexed data. We then show experimental results with real datasets and brief security analyses in order to establish the practical value of our proposed solutions. Finally, the last section gives conclusions and future work.

RELATED WORK

Although various theoretical problems concerning computation with encrypted data and searching on encrypted data have appeared in the literature (Fong, 2003), the ODBS model which heavily depends on data encryption methods emerged not long ago (Du & Atallah, 2000; Hacigümüs, Mehrotra, & Iyer, 2002b; Dang, 2006b). Even then it rapidly got special attention from the research community due to a variety of conveniences brought in as well as interesting research challenges related (Dang, 2005). The foremost research challenge relating to security objectives for the model was introduced in the previous section. In Figure 2 we diagrammatically summarize security issues in the ODBS model, together with major references to the corresponding state-of-the-art solutions.

As shown in Figure 2, most security objectives of the ODBS model have been investigated. To deal with data confidentiality issue, most approaches adopted to encrypt (outsourced) data before its

Figure 2. Security issues in the ODBS model



being stored at the external server (Bouganim & Pucheral, 2002; Damiani et al., 2003; Dang, 2005). Although this solution can protect the data from outsiders as well as the server, it introduces difficulties in the querying process, as it is hard to ensure the user and data privacy when performing queries over encrypted data.

In general, to address the privacy issue (including both user and data privacy), outsourced data structures (tree or non-tree based) that are employed to manage the data storage and retrieval should be considered. Notably, the problem of *user privacy* has been well solved, even without special hardware (Smith & Safford, 2001), if the outsourced database contains only encrypted records and no tree-based indexes are used for storage and retrieval purposes (see Dang, 2006b, for an overview). Conversely, the research result is less incentive if such trees are employed, although some proposals have been made recently (Lin & Candan, 2004; Dang, 2006b). In our previous work (Dang, 2006b), we did propose an *extreme protocol* for the ODBS model based on private information retrieval (PIR)-like protocols (Asonov, 2001). It would, however, become prohibitively expensive if only one server were used to host the outsourced data (Chor, Goldreich, Kushilevitz, & Sudan, 1995). Damiani et al. (2003) also gave a solution to query-outsourced data indexed by B^+-trees, but their approach does not provide an obvious way to traverse the tree, and this may lead to compromised security objectives (Lin & Candan, 2004; Dang, 2006a). Lin and Candan (2004) introduced a computational complexity approach to solve the problem with sound experimental results reported. Their solution, however, only supports obvious search operations on outsourced search trees, insert, delete, and modification ones. That means their solution cannot be applied to *dynamic* outsourced search trees where several items may be inserted into and removed from, or existing data can be modified. In our recent work (Dang, 2006a), we analyzed and introduced techniques to completely solve the problem of data confidentiality and user privacy, but query assurance, in the ODBS model with dynamic tree-indexed data supports. In the next sections we will elaborate on these techniques and extend them in order to deal with the three security objectives of query assurance as mentioned above.

Contrary to user privacy, although there are initial research activities (Gertner, Ishai, Kushilevitz, & Malkin, 1998; Du & Atallah, 2000; Dang, 2006b), the problem of data privacy still needs much more attention. Gertner et al. (1998) first considered the data privacy issue in the context of PIR-like protocols and proposed the so-called SPIR, symmetrical PIR, protocol in order to prevent users from knowing more than the answers to their queries. Unfortunately, such PIR-based approaches cannot be applied to the ODBS model because the data owners in PIR-like protocols are themselves the database service providers. Du and Atallah (2000) introduced protocols for secure remote database access with approximate matching with respect to four different ODBS models requiring different security objectives among those presented in the previous section. Even so, their work did not support outsourced tree-indexed data. In our recent work (Dang, 2006b), we presented a solution to ensuring data privacy in the ODBS model which can be applied to tree-indexed data as well. Nevertheless, our proposed solution must resort to a *trusted* third party, which is not easy to find in practice.

Recently, addressing the three issues of query assurance has also attracted many researchers and, as a result, a number of solutions have been proposed (e.g., Boneh et al., 2003; Mykletun et al., 2004; Pang & Tan, 2004; Pang et al., 2005; Narasimha & Tsudik, 2006; Sion, 2005; Nguyen, Dang, Son, & Kueng, 2007). We must even now note that *none of them has given a solution to the problem of guaranteeing the query result freshness* (see Figure 2).[3] To prove the correctness of a user's query results, the state-of-the-art approaches (Boneh et al., 2003; Mykletun et al., 2004; Pang & Tan, 2004; Sion, 2005) employed

some aggregated/condensed digital signature scheme to reduce the communication and computation costs. First, Boneh et al. (2003) introduced an interesting aggregated signature scheme that allows aggregation of multiple signers' signatures generated from different messages into one short signature based on elliptic curves and bilinear mappings. This scheme was built based on a "Gap Diffie-Hellman" group where the Decisional Diffie-Hellman problem is easy while the Computational Diffie-Hellman problem is hard (Joux & Nguyen, 2001). Despite the big advantage that this scheme can be applied to different ODBS models, it must bear a disadvantage related to the performance. As shown in Mykletun et al. (2004), the computational complexity of Boneh et al.'s (2003) scheme is quite high for practical uses in many cases. Second, Mykletun et al. (2004) introduced a RSA-based condensed digital signature scheme that can be used for ensuring authenticity and data integrity in the ODBS model. Their scheme is concisely summarized as follows.

Condensed-RSA Digital Signature Scheme

Suppose pk=(n, e) and sk=(n, d) are the public and private keys, respectively, of the RSA signature scheme, where n is a k-bit modulus formed as the product of two k/2-bit primes p and q. Assume $\varphi(n)$=(p-1)(q-1), both public and private exponents e, d$\in Z_n^*$ and must satisfy ed $\equiv$ 1 mod $\varphi(n)$. Given t different messages $\{m_1, ..., m_t\}$ and their corresponding signatures $\{s_1, ..., s_t\}$ that are generated by the *same* signer, a condensed-RSA signature is computed as follows: $s_{1,t}=\prod_{i=1}^{t} s_i$ mod n. This signature is of the same size as a single standard RSA signature. To verify the correctness of t received messages, the user must multiply the hashes of all t messages and check that $(s_{1,t})^e \equiv \prod_{i=1}^{t} h(m_i)$ mod n.

As we can see, the above scheme is possible due to the fact that RSA is *multiplicatively homomorphic*. We will apply this scheme to our ODBS model in order to provide correctness guarantees of the received tree nodes from the server (see the section on "Correctness Guarantees"). Note that, however, this scheme is applicable only for a single signer's signatures. Sion (2005) also employed this approach to deal with the correctness of query results in his scheme. Besides, Pang and Tan (2004) applied and modified the idea of "Merkle Hash Trees" (MHT) (Merkle, 1980) to provide a proof of correctness for edge computing applications, where a trusted central server outsources parts of the database to proxy servers located at the edge of the network. In Narasimha and Tsudik (2006), however, the authors pointed out possible security flaws in this approach.

Furthermore, there are also some approaches to deal with the completeness of a user's query results (Sion, 2005; Pang et al., 2005; Narasimha & Tsudik, 2006). First, Sion (2005) proposed a solution to provide such assurances for arbitrary queries in outsourced database frameworks. The solution is built around a mechanism of runtime query "proofs" in a challenge-response protocol. More concretely, before outsourcing the data, the data owner partitions its data into k segments $\{S_1, ..., S_k\}$, computes hashes for each segment, $H(S_i)$, $i=\overline{1,k}$, then stores (outsources) them all together at the service provider's server. In addition, the data owner also calculates some "challenge tokens" with respect to S_i. Actually, the challenge tokens are queries that the data owner already knows their results, which can be used for verification later. Whenever a *batch* of queries are sent to the server, certain challenge token(s) are also sent together. The result set is then verified using the challenge tokens for its completeness. Although this approach can be applied to different query types, not 100% of the query assurance (the completeness) can be guaranteed because there are chances for a malicious server to "get away" with cheating in the query execution phase (i.e., the server only needs to "guess" and return the correct answer to the challenge token together with fake result sets for other queries in the batch,

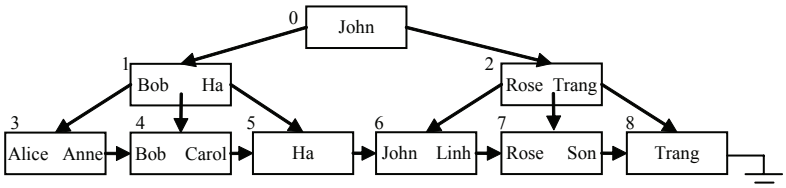
but nothing else). Moreover, this approach also introduces cost inefficiency for database updates because the challenging answers must be recalculated. Seriously, although the author did not aim to address the user privacy issue in the article, we should note that user privacy in this approach may be compromised because the server knows what data segments are required by the user so *inference and linking attacks* can be conducted (Dang, 2006b; Damiani et al., 2003). Second, Pang et al. (2005) introduced a solution based on aggregated signature schemes and MHT to provide the completeness of the query result. This approach is an extension of that presented in their previous work (Pang & Tan, 2004), which has been proven insecure due to some possible security flaws (Narasimha & Tsudik, 2006). Last, Narasimha and Tsudik (2006) developed an approach, called digital signature aggregation and chaining (DSAC), which achieves both correctness and completeness of query replies. However, in their approach, tuples must be pre-sorted in ascending order with respect to each searchable dimension for calculation of the signature chain, and thus it still does not support outsourced tree-indexed data where the order of tree nodes' contents is not able to be determined. This pre-sorting requirement also has a negatively tremendous impact on data updates, hence the total performance of the system will be degenerated.

Apart from the security issues mentioned above and in the previous section, as we can observe in Figure 2, there exists another question: How can the server conduct *auditing activities* in systems provided with such security guarantees (without employing special hardware equipment)? The server may not know who is accessing the system (e.g., Dang, 2006b), what they are asking for, what the system returns to the user, and thus how it can effectively and efficiently tackle the accountability or develop intrusion detection/prevention systems. The goals of privacy-preserving and accountability appear to be in contradiction, and an efficient solution to balance the two is still open. More discussions about this topic can be found in Burmester, Desmedt, Wright, and Yasinsac (2004). In the next section we will elaborate on the state-of-the-art approach proposed in Dang (2006a) to managing the storage and retrieval of dynamic outsourced tree-indexed data, and in the section after that we will extend this approach to strengthen it with query assurance supports, including all the three concerned security objectives.

A PRAGMATIC APPROACH TO MANAGING OUTSOURCED TREE-INDEXED DATA

As discussed in the literature, tree-based index structures take an indispensable role in both traditional and modern database applications (Dang, 2003). However, in spite of their advantages these index structures introduce a variety of difficulties in the ODBS model (Du & Atallah, 2000; Dang, 2006b). To detail the problem, Figure 3a illustrates an example of the B^+-tree for an attribute *CustomerName* with sample values. All tree nodes were encrypted before being stored at the outsourcing server to ensure the data confidentiality. Assume that a user is querying all customers whose name is *Ha* on this tree. If we do not have a secure mechanism for the query processing, a sequence of queries that will access in sequence nodes 0, 1, and 5 with respect to the above query will be revealed to the server. In addition, the server also realizes that the user was accessing nodes 0, 1, and 5, and node 0 is the root, node 1 is an internal node, node 5 is a leaf node of the tree, and so the user privacy is compromised. More seriously, using such information collected gradually, together with statistical methods, data mining techniques, and so forth, the server can rebuild the whole tree structure and infer sensitive information from the encrypted database, hence data confidentiality can also be spoiled. Besides, during the querying, the user will also

Figure 3. An example of the B⁺-tree (a) and the corresponding plaintext and encrypted table (b)



(a) B+Tree

NID	Node
0	(1,John,2,-,-1)
1	(3,Bob,4,Ha,5)
2	(6,Rose,7,Trang,8)
3	(Alice,Anne,4)
4	(Bob,Carol,5)
5	(Ha,-,6)
6	(John,Linh,7)
7	(Rose,Son,8)
8	(Trang,-,-1)

NID	EncryptedNode
0	D0a1n2g3Kh75nhs&
1	T9&8ra§ÖÄajh³q91
2	H&$uye”µnÜis57ß@
3	L?{inh*ß²³&§gnaD
4	Wh09a/[%?Ö*#Aj2k
5	j8Hß}[aHo$§angµG
6	#Xyi29?ß~R@€>Kh
7	~B³!jKDÖbd0K3}%§
8	T-§µran&gU19=75m

(b) B+Table and B+EncryptedTable

get more information showing that there are at least two other customers named *John* and *Bob* in the database, so the data privacy is not satisfied (note that, however, we will not address the data privacy problem in this article).

Although Damiani et al. (2003) proposed an approach to outsourced tree-based index structures, it unfortunately has some security flaws that may compromise the desired security objectives (Dang, 2005, 2006b). Lin and Candan (2004) and Dang (2006a) developed algorithms based on access redundancy and node-swapping techniques to address security issues of outsourced tree-indexed data. We briefly summarize their solutions in the rest of this section.

Obviously, as private data is outsourced with search trees, the tree structure and data should all be confidential. As shown in Damiani et al. (2003), encrypting each tree node as a whole is preferable because protecting a tree-based index by encrypting each of its fields would disclose to the server the ordering relationship between the index values. Lin and Candan's (2004) approach also follows this solution and, like others (Dang, 2005, 2006a; Damiani et al., 2003), the unit of storage and access in their approach is also a tree node. Each node is identified by a unique *node identifier* (NID). The original tree is then stored at the server as a table with two attributes: NID and an encrypted value representing the node content. Consider an example: Figure 3a shows a B⁺-tree built on an attribute *CustomerName*; Figure 3b shows the corresponding plaintext and encrypted table used to store the B⁺-tree at the external server. As we can see, that B⁺-tree is stored at the external server as a table over schema B⁺EncryptedTable = {NID, EncryptedNode}.

Based on the above settings, Lin and Candan (2004) proposed an approach to oblivious

traversal of outsourced search trees using two adjustable techniques: *access redundancy* and *node swapping*.

Access Redundancy

Whenever a user accesses a node, called the target node, it asks for a set of m-1 randomly selected nodes in addition to the target node from the server. Hence, the probability that the server can guess the target node is 1/m. This technique is different from those presented in Damiani et al. (2003), where only the target node is retrieved (this may lead to reveal the tree structure as shown in Dang, 2005, 2006b). Besides the access redundancy, it also bears another weakness: it can leak information on the target node position. This is easy to observe: multiple access requests for the root node will reveal its position by simply calculating the intersection of the redundancy sets of the requests. If the root position is disclosed, there is a high risk that its child nodes (and also the whole tree structure) may be exposed (Lin & Candan, 2004). This deficiency is overcome by secretly changing the target node's address after each time it is accessed.

Node Swapping

Each time a user requests to access a node from the server, it asks for a *redundancy set* of m nodes consisting of at least one empty node along with the target one. The user then: (1) decrypts the target node, (2) manipulates its data, (3) swaps it with the empty node, and (4) re-encrypts all m nodes and writes them back to the server. Note that this technique must re-encrypt nodes using a different encryption scheme/key (see Lin & Candan, 2004, for details). The authors proved that, with this technique, the possible position of the target node is randomly distributed over the data storage space at the untrusted server, and thus the weakness of the access redundancy technique is overcome.

Additional Procedures

To realize oblivious traversal of outsourced search trees, some more critical issues must also be addressed:

- **Managing root node address:** The authors proposed to employ a special entry node called SNODE whose NID and decryption key are known to all valid users. It keeps pointers ROOTS pointing to the root nodes of all outsourced search trees that the user can access.
- **Managing empty node lists:** Empty nodes are stored in hidden linked lists. To help users find out the empty nodes, two other types of pointers are also stored in the SNODE: EHEADS and ETAILS point to the heads and tails of empty node lists, respectively.
- **Random choice for redundancy sets:** A redundancy set consists of the target node, an empty node, and m-2 randomly selected nodes. To enable users to do this, the SNODE records the range of NIDs of nodes in the data storage space at the server. The user will then be able to generate m-2 random NIDs within the range.
- **Managing the tree structure integrity:** This aims to maintain node/parent-node relationships after the node swapping. The first solution is to find the empty node to be swapped with the child node and update the parent node accordingly before actually swapping the child node. The second solution is to let users keep track of all nodes from the root down, deferring all the swaps until the node containing the data is accessed.
- **Concurrency control in the multi-user environment:** The authors also presented a solution to concurrency control without deadlocks. The main idea of the proposed solution is to organize nodes in the data storage space at the server into d levels,

and each level requires an empty node list to store empty nodes at this level. Besides, all users access nodes in some fixed predetermined order, ensuring deadlock-free access in a multi-user environment. See Lin and Candan (2004) for detailed discussions about the proposed solutions to all of these critical issues.

Although Lin and Candan's (2004) approach only supports *oblivious* tree search operations, the two above techniques have served as the basis for our further investigation. Based on the access redundancy and node-swapping techniques, in Dang (2006a) we developed practical algorithms for privacy-preserving search, insert, delete, and modify operations that can be applied to a variety of *dynamic* outsourced tree-based index structures and the *unified user* model where data owners are also sole users of the system (see Mykletun et al., 2004; Du & Atallah, 2000; Dang, 2006b, for more details about ODBS models). Although our previous work provided the vanguard solutions for this problem with sound empirical results, it did not consider the query assurance problem. In the next section we will extend our previous work to address this problem. Note that, however, as with the unified user model, it is not necessary to take into account, in the remainder of this article, the clients as shown in Figure 1. The key "actors" in our concerned ODBS model now consist only of *the data owners* and *the outsourcing database server.*

QUERY ASSURANCE FOR OUTSOURCED TREE-INDEXED DATA

In this section, we present an extension of our previous work in Dang (2006a), which introduced solutions to the problems of data confidentiality and user privacy in the ODBS model (with respect to the unified user model), in order to incorporate solutions to ensuring the correctness, completeness, and freshness of the query results. The next section will detail the experimental results with real datasets.

Correctness Guarantees

As introduced in the first section, to guarantee the correctness of the query result set, the system must provide a means for the user to verify that the received data originated from the data owner as it is. As analyzed in previous sections, the state of the art employed the public key cryptography scheme to deal with this problem. With respect to our concerned ODBS model, where data privacy considerations are omitted and only single signer (i.e., only one data owner or multiple data owners using the same signature scheme) participates in the query processing, the RSA-based signature scheme is the most suitable as already discussed.

In our context, outsourced tree-indexed data is stored at the server side as described in the previous section—that is, as a table over schema EncryptedTable = {NID, EncryptedNode}. Before outsourcing the data, the data owner computes the hash h(m) of each encrypted node m. Here, h() denotes a cryptographically strong hash function (e.g., SHA-1). The data owner then "signs" that encrypted node m by encrypting h(m) with its private/secret key sk and stores the signatures together with EncryptedTable at the server. The table schema stored at the server therefore becomes *EncryptedTable = {NID, EncryptedNode, Signature}* (see Figure 4).[4] With these settings, users[5] can then verify each returned node using the data owner public key pk, hence ensuring the correctness of the result set.

Although the *naive* approach above ensures the security objective, it is expensive because the number of signatures to verify equals the redundancy set size. To solve this issue, we employ the condensed-RSA digital signature scheme based on the fact that RSA is multiplicatively homomorphic

Figure 4. EncryptedTable with tree node contents' signatures

B+Table

NID	Node
0	(1,John,2,-,-1)
1	(3,Bob,4,Ha,5)
2	(6,Rose,7,Trang,8)
3	(Alice,Anne,4)
4	(Bob,Carol,5)
5	(Ha,-,6)
6	(John,Linh,7)
7	(Rose,Son,8)
8	(Trang,-,-1)

B+EncryptedTable

NID	EncryptedNode	Signature
0	D0a1n2g3Kh75nhs&	s0
1	T9&8ra§ÖÄajh³q91	s1
2	H&$uye"µnÜis57ß@	s2
3	L?{inh*ß²³&§gnaD	s3
4	Wh09a/[%?Ö*#Aj2k	s4
5	j8Hß}[aHo$§angµG	s5
6	#Xyi29?ß~R@€>Kh	s6
7	~B³!jKDÖbd0K3}%§	s7
8	T-§µran&gU19=75m	s8

as presented in the previous section as follows: Given t input encrypted nodes $\{m_1, ..., m_t\}$ (the redundancy set) and their corresponding signatures $\{s_1, ..., s_t\}$, the server computes a condensed-RSA signature $s_{1,t}$ as the product of these individual signatures and sends it together with the redundancy set to the user. The user, in turn, will be able to verify the condensed signature $s_{1,t}$ by employing the hashes computed from all received nodes (in the corresponding redundancy set) as shown in the previous section. With this method, not only the query result correctness is ensured, but both communication and computation costs are also tremendously reduced. Note that in this case the server has to send only one condensed-RSA signature $s_{1,t}$ to the user for verification instead of t individual ones. In the following section we will show the experimental results.

Completeness Guarantees

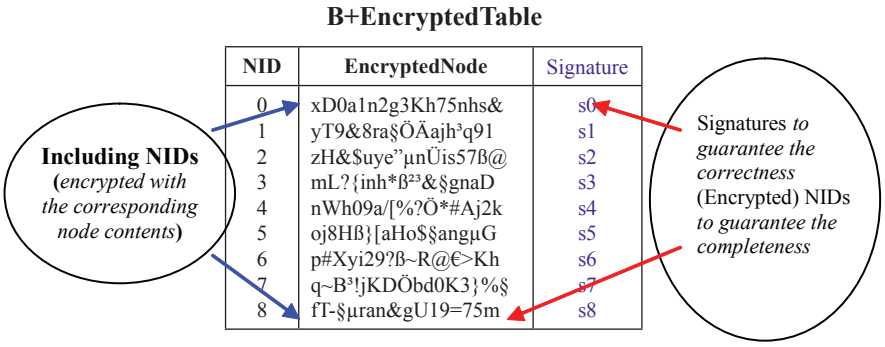
Completeness guarantees mean that the server did not omit any tuples matching the query conditions. In our context, as a user asks the server for a redundancy set A of t nodes $A=\{m_1, ..., m_t\}$ and the server returns him a set R of t nodes $R=\{n_1, ..., n_t\}$, the user must be able to verify that A=R. As presented in the previous section, a user asks for any encrypted nodes (at the server side) through their NIDs. Therefore, the user should be provided with a means of verifying that NID of each m_i, $i=\overline{1,t}$, equals NID of each corresponding n_i, $i=\overline{1,t}$. To ensure this, our solution is embarrassingly simple: an NID is encrypted with the corresponding node contents and this encrypted value is stored at the server side, together with its signature. Users can then check if the server returned the NIDs (in the redundancy set) that he or she did require (the completeness) as well as verify the query result correctness (as shown in the section, "Correctness Guarantees"). This idea is clearly illustrated in Figure 5.

In more detail, Figure 5 sketches settings for verifying completeness (and correctness) guarantees of the system. First, the encrypted value with respect to the attribute *EncryptedNode* also includes the NID of its corresponding node (for example, in the first row, the encrypted value also includes value 0). Second, the data owner signs each encrypted node using the RSA signature scheme, then stores the signature (e.g., s_0) together with the NID and its corresponding encrypted value as described in the previous section. Note that, however, verifying the completeness and the correctness must be carried out together—that is, the user cannot omit any of them and still be ensured that the other is also guaranteed. This is also true for freshness guarantees that we will present below.

Freshness Guarantees

As discussed previously, with *dynamic* outsourced databases, ensuring only the correctness and

Figure 5. Settings for verifying completeness guarantees

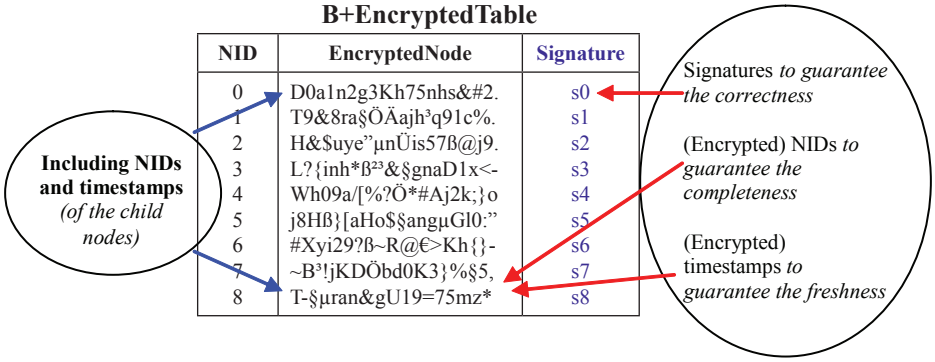


completeness of the result set is not enough. Apart from those, the system must also provide a means for users to verify that the received nodes are from the most recent database state, not the older one(s). Either motivating by clear cost incentives for dishonest behavior or due to intrusions/viruses, the server may return users *obsolete* nodes, which do not truly reflect the state of the outsourced database at the querying time. This is not a less important problem that also needs to be sorted out to make the ODBS model viable. Narasimha and Tsudik (2006) mention this problem and outline a possible solution based on MHTs, but no cost evaluation is given. Note that MHT-based approaches to the ODBS model are quite expensive, especially for *dynamic* outsourced tree-indexed data (Narasimha & Tsudik, 2006). In this section, we propose a vanguard solution to this problem, and a comprehensive evaluation for all concerned security objectives will be presented in the next section.

To solve the problem of freshness guarantees, users must be able to verify that the server did return them the most up-to-date required tree nodes (at the time it processed the query). Our solution is also quite simple, but sound and complete, based on timestamps: A timestamp of each child node is stored at its parent node. This timestamp changes *only* as the child node *contents* (but not its address) are updated. In other words, a node keeps timestamps of all of its child nodes, and a user can then check (from the root node) if the server returned him the latest version of the required node as follows: In accessing the root, the user knows in advance all timestamps of its child nodes, and as a child node is returned, he or she can check if this node's timestamp equals the known value, and so on. This process is carried out for every tree node required by the user.

There is, however, one question that arises: How can users check the root's timestamp? The answer to this question is not complicated: In the settings for access redundancy and node-swapping techniques, there is a special node called SNODE that keeps some metadata and the root's address (see the previous section). The SNODE's address and its decryption key are known to all qualified users. Besides, in the context of our concerned ODBS model, only data owners are able to make changes to, as well as to query, their outsourced data. Therefore, for the sake of freshness guarantees, SNODE will keep the timestamp of the root in addition to other information as mentioned before (this timestamp changes only as *the root contents* are updated by a data owner), and each qualified user (i.e., other data owners) is informed about the timestamp of SNODE (by the data owner who made the changes[6]). Moreover, with the settings for access redundancy and node-swapping techniques, besides the root's address and timestamp, the users must also use *other metadata in the SNODE* for performing operations on the

Figure 6. Settings for verifying freshness guarantees



tree (see Dang, 2006a, for detailed discussions about the outsourced tree operations). Hence, it is vitally important that the SNODE's timestamp is communicated to all users as discussed above to ensure the freshness of the result set.

Overall, with all of these above settings, all the three security objectives of the query assurance problem in the concerned ODBS model—that is, the correctness, completeness, and freshness guarantees of the query result—can be effectively verified. Note that the encrypted value representing the corresponding node contents now includes not only its NID, but also timestamps of the child nodes. The corresponding signature is computed based on this final encrypted value. This is clearly illustrated in Figure 6.

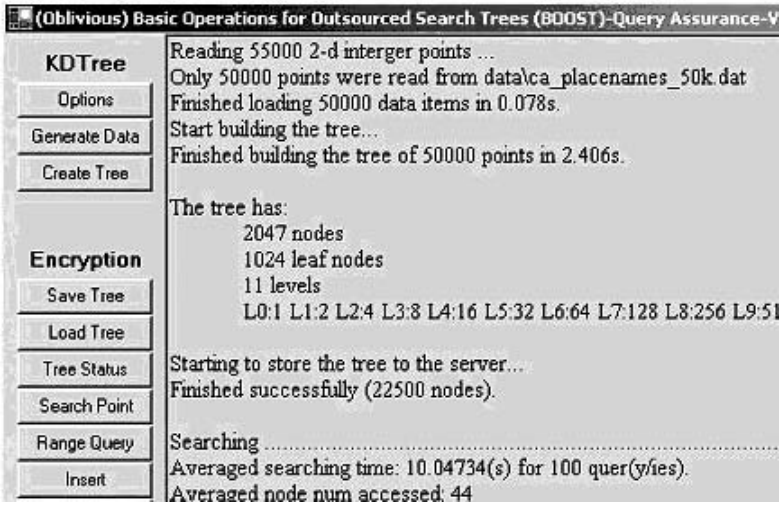
EXPERIMENTAL RESULTS

To confirm theoretical analyses carried out in previous sections and establish the practical applicability of our approach, we implemented a prototype system and evaluated the proposed solutions with real datasets. For all experiments, we used two-dimensional datasets, which were extracted from the SEQUOIA dataset at http://www.rtreeportal.org/spatial.html. The SEQUOIA dataset consists of two-dimensional points of the format (x, y), representing locations of 62,556 California place names. We extracted five subdatasets of 10K, 20K, 30K, 40K, and 50K points from the SEQUOIA dataset for experiments.

To manage the spatial points, we employed two-dimensional kd-trees due to its simplicity. For all the trees, we set the maximum number M of data items that a leaf node can keep to 50 and the *minimum fill factor* value to 4%. This means that each tree leaf node must contain at least two points and can store up to 50 points. Furthermore, the tree was stored in a data storage space with 22,500-node capacity (see Figure 7), divided into 15 levels of 1,500 nodes each (see Dang, 2006a; Lin & Candan, 2004, for detailed meanings of these settings).

Our prototype system consisted of only one P4 CPU 2.8GHz/1GB RAM PC running a Windows 2003 server. Both user and server were accommodated in the same computer, so for all experiments, we will report average time to complete a user request, which can represent the average CPU cost of each user request and analyze averaged IO and communication cost. In addition, all programs were implemented using C#/Visual Studio .NET 2003, and we employed the DES algorithm for the encryption of data and the RSA signature scheme (1024 bits key) with SHA-1 hashing for the digital signatures. We did experiments with all major basic operations, including search (for both point and range queries) and updates (inserts and deletes). Note that *modify*

Figure 7. A screen shot: Costs of point and range queries with condensed-RSA scheme wrt. 50K points dataset



operations are combinations of inserts and deletes (Dang, 2005, 2006a).

In addition, because there is no previous work built on the same or similar scheme and addressing the same problem, we had to build our scheme from scratch and did experiments to evaluate our solutions to the query assurance issue on the basis of the condensed-RSA signature scheme and the naive/standard RSA signature scheme. All the security objectives of the query assurance issue (i.e., correctness, completeness, and freshness guarantees) were taken into account. The details are as follows.

Initially, we did experiments with the largest dataset, 50K points, for insert, delete, point, and range queries in order to see the performance of both naive and condensed RSA-based solutions. The *redundancy set* size is set to 4 for the tests. Figure 7 shows a screen shot as we built the tree, stored it to the server, and performed point and range queries with condensed-RSA scheme wrt. the largest dataset. In Figure 8, we present the experimental results concerning the CPU cost for all operations. It is clearly shown that the condensed-RSA scheme CPU cost is much better than that of the naïve-RSA scheme. Note that the average accessed node number (i.e., the IO cost) of the two is the same, but the communication cost of the condensed-RSA scheme is also better by a factor of *(Redundancy_set_size -1) * RSA_signature_size*. This is due to the fact that as with the condensed-RSA scheme, the server has to send the user only *one condensed signature,* while it has to send *Redundancy_set_size* signatures with respect to the naïve-RSA scheme. Verifying more signatures is the main reason for a higher CPU cost of the latter.

Furthermore, to see the effect of different database sizes on the performance for each sub-dataset, we ran 100 separate queries with the redundancy set size being set to 4, and calculated averaged values for CPU time. With inserts, deletes, and point queries, we randomly chose 100 points from the corresponding dataset as the queries. With range queries, we randomly chose 100 squares as the queries. The sides of each square were chosen to be 1% of the norm of the data space side (if the dataset is uniformly distributed, this value maintains the selectivity of 0.01% for these range queries).The experimental results are shown

Figure 8. Condensed RSA signature scheme vs. naive RSA signature scheme

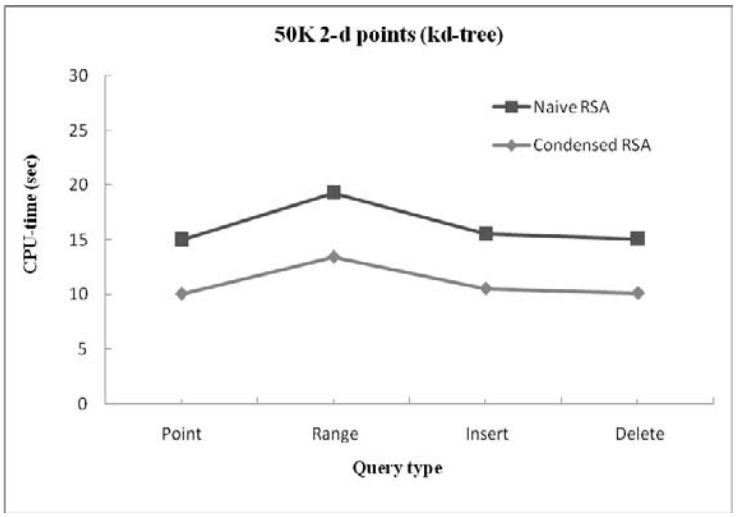
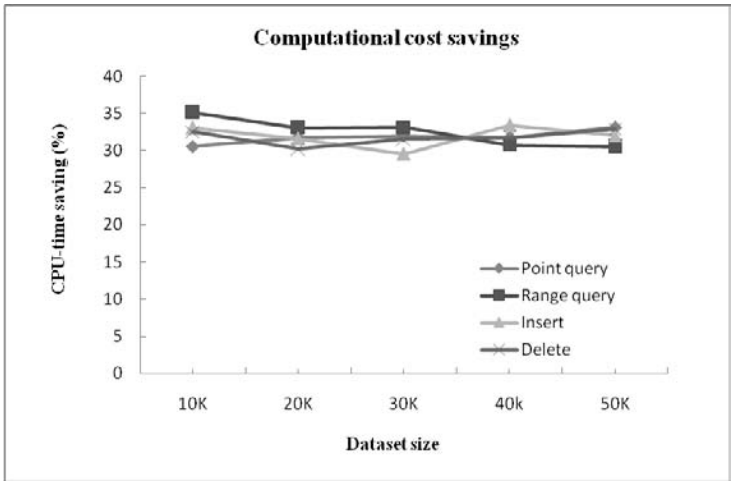


Figure 9. A variety of dataset sizes



in Figure 9. As we can see, the CPU cost saving of all kinds of queries is high, over 30% at the minimum between the condensed-RSA scheme and the naïve-RSA scheme. Again, as mentioned above, although the average accessed node number is equal for both schemes, the communication cost of the condensed-RSA scheme is better than that of the naïve-RSA scheme.

Security Analysis Briefings

The security correctness of our proposed solutions to all the three security objectives in our holistic approach to the query assurance problem in the ODBS model is obvious and can be understood from discussions and analyses in previous sections. However, one may question the security degree of access redundancy and node-swapping techniques introduced in Lin and

Candan (2004) and their *modified versions* for dynamic outsourced search trees (Dang, 2005, 2006a). The proof of the security correctness is therefore focused on that of the previous work. Fortunately, Dang (2006a) and Lin and Candan (2004) did prove that when users access the outsourced tree-indexed data, the untrusted server is not able to determine if any two queries are identical and, for two different queries, it is also not able to differentiate the distribution of the queries' redundancy sets in polynomial time. The former is to protect queries from the server and the latter aims to protect the tree structure. In summary, to conclude this section we emphasize that it has been mathematically proven in Lin and Candan (2004) and Dang (2006a) that our approach, based on the access redundancy and node-swapping techniques, is computationally secure to protect both queries and the tree structure from a polynomial time server. Hence, it is quite safe to claim that our proposed solutions in this article, which have extended the previous work, become full-fledged and can be applied to real-world ODBS models.

CONCLUSION AND FUTURE WORK

In this article, we explored the problem of query assurance in the outsourced database service (ODBS) model. Concretely, we extended our previous work (Dang, 2006a) and presented a full-fledged solution to the problem of ensuring the *correctness, completeness,* and *freshness* for basic operations (insert, delete, modify, point, and range queries) on dynamic outsourced tree-indexed data. Experimental results with real multidimensional datasets have confirmed the efficiency of our proposed solution. Notably, to the best of our knowledge, none of the previous work has dealt with all the three above security issues of query assurance in the ODBS model with respect to dynamic outsourced trees. Our work therefore provides a vanguard solution for this problem. Also, this work can also be applied to non-tree-indexed data outsourced to untrusted servers (with settings like those of Damiani et al., 2003; Dang, 2006a).

Our future work will focus on evaluating the efficiency of the proposed solutions in real-world applications and on addressing related open research issues. Specially, supporting multiple data owners' signatures (i.e., multiple signers) is a generalization of the proposed solution in this article. An efficient solution to this problem is still open. Moreover, as discussed in the section "Related Work," auditing and accountability for the ODBS model, as well as computer criminal-related issues and the data privacy problem, should be addressed, and they will be among our future research activities of great interest. Another problem also attracts us: how to deal with the problem of *over redundancy* of the result set returned from the server—that is, the server sends the user more than what should be returned in the answers. This may cause a user to pay more for the communication cost, to incur higher computation costs, and so this issue needs to be investigated carefully.

ACKNOWLEDGMENT

The author would like to thank the anonymous referees for their insightful reviews with interesting comments and suggestions.

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ENDNOTES

1 In this article, however, we will deal with a less complicated ODBS model.

2 Note that, although privacy-related issues have been widely investigated (PRIME Project, 2004), the question "what is the complexity of the privacy problem?" is still open inasmuch as the answer is quite different, depending not only on technology, but also on sociology and politics (Thuraisingham, 2005).

3 In one of our very recent papers (Nguyen et al., 2007), which was written and published after this article had been accepted for publication, we also employed the timestamps as proposed in this article in order to ensure the query result freshness of dynamic outsourced XML databases.

4 Note that Figure 4 depicts only "real" tree nodes, but the empty nodes that are not shown here are also stored in the same table, EncryptedTable, over the same schema at

the server side (see Dang, 2006a, for more information).

[5] Here, in the unified user model, a user is also one of the data owners.

[6] Obviously, the data owner knows who the valid users/other data owners are, and so this solution is well applicable.

This work was previously published in the Information Resources Management Journal, Vol. 21, Issue 1, edited by M. Khosrow-Pour, pp. 59-76, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 5
The Post-Offshoring IS Organization

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ABSTRACT

In the age in which many traditional IS functions will be taken over by offshore vendors or otherwise outsourced, attention needs to be paid to those functions that will increase in importance and/or need to be developed by IS departments if they are to be effective in this new environment. This article suggests a framework that may be judgmentally applied to IS activities in order to determine if they should be considered for offshoring/outsourcing. The results of applying the framework will be unique to each firm that uses it. However, in using that approach in more than 25 firms, the author has found that most firms will wish to retain a number of functions in-house. Fourteen such activities are discussed in three broad categories: "activities related to external relations," "activities related to the development, customization, and implementation of systems" and "business and IS strategic activities."

INTRODUCTION

The offshore outsourcing of IT has become an import aspect of IS management as more and more IT activities are sent offshore. This trend has been driven by the twin imperatives of investment minimization and labor arbitrage.

Companies and IS departments are motivated to reduce fast-rising fixed costs, especially of personnel benefits, in order to increase "ROI," or whatever version of it is applied to the IS function. At the same time, significant labor-cost savings are achievable using vendors in India and other less-developed nations, making cost savings a major opportunity.

An Association for Computing Machinery Report (Aspray, Mayadas, & Vardi, 2006) delineates six varieties of work related to IS that are often offshored: (1) programming, software testing, and software maintenance; (2) IT research and development; (3) high-end jobs such as software architecture, product design, project management,

IT consulting, and business strategy; (4) physical product manufacturing—semiconductors, computer components, computers; (5) business process outsourcing/IT-enabled services—insurance claim processing, medical billing, accounting, bookkeeping, medical transcription, digitization of engineering drawings, desktop publishing, and high-end IT enabled services such as financial analysis and reading of X-rays; and (6) call centers and telemarketing. Some of these are more relevant to future IS organizational management than are others.

The rapid growth of offshoring has taken place in a context in which many businesses have been moving away from focusing on a strategy of risk-moderation through a diversified portfolio of activities to a focus on "core" activities, with "commodity" activities being outsourced to specialists. Many aspects of IT are believed to be commodities by business executives who have been persuaded by the logic that much of IT can be obtained through the market, that it is available to anyone, and that it therefore can provide no competitive advantage (Carr, 2003). This may be true for some of the basic IT infrastructure of the organization, but it is not so for many of the other IT-enabled processes of the firm.

In fact, a problem that has arisen from the "core vs. commodity" dichotomy is that there are many IT-enabled business activities that are neither one or the other; instead, they are complex combinations of both. Consequently, many firms have outsourced what they believed were non-core, commodity business processes only to find that some outsourced processes contained core IT capabilities that should have been retained (Barthelemy, 2003; Saunders, Gebelt, & Hu, 1997).

Nonetheless, the offshoring of IS activities continues unabated. This is likely to continue in the future (Davis, Ein-dor, King, & Torkzadeh, 2007), and it will have profound effect on the IS organization—new skills and capabilities will be needed; the need for some traditional capabilities will virtually disappear; the priorities that need to be placed on other existing capabilities will need to shift radically.

Among the capabilities that will clearly need to be downgraded in this new environment are some of those in traditional systems development, since much of the organization's software will be purchased from vendors and customized to fit the organization's unique needs or will be developed on an outsourced basis. But, the desirability of outsourcing/offshoring of many other IS activities is not at all clear.

This article attempts to identify those "non-outsourcable" IS activities that will need to be initiated or given greater prominence in this new post-offshoring environment using explicit criteria that go beyond the simplistic "core vs. commodity" dichotomy.

VIEWS OF IT CORE CAPABILITIES

The closest notion to that of a "non-outsourcable" activity is that of a core IT capability. Feeney and Wilcocks (1998) identified three "recurring, fundamental (IT) issues a company faces, whatever the contemporary specifics of business circumstances or IT product" (p. 10): the need for two-way strategic alignment between business and technology, the delivery of IS services at low cost and high quality, and the design of IT architecture.

Based on a study of practice in these three areas, they identified core IS capabilities that are "required both to underpin the pursuit of high-value-added applications of IT and to capitalize on the external market's ability to deliver cost-effective IT services" (p. 12):

- leadership,
- business systems thinking,
- relationship building (between is and business people and organizations),
- architecture planning,
- making technology work,

- informed buying,
- contract facilitation,
- contract monitoring,
- vendor development, and
- project management.[1]

Ross, Beath, and Goodhue (1996) similarly identified three key assets that the IS function must create and leverage: (1) highly competent IT human resources, (2) a reusable technology base, and (3) a strong partnering relationship between IT and business management.

Peppard, Lambert, and Edwards (2000) adopted a perspective that transcended the IS function: "The competencies necessary for success with IS are not located within a single function—specifically the IS function" (Peppard & Ward, 2004, p. 176). Peppard and Ward (2004) then identified six "macro competencies:" strategy, defining the IS contribution, defining the IS capability, exploitation, delivering solutions, and supply, as well as 26 specific competencies that make up these six macro competencies.

All of the specifications of core IT capabilities should be used as guidance by anyone giving consideration to outsourcing/offshoring.

A POST-OFFSHORING FRAMEWORK

At this broad level of granularity, one might conclude that none of the core capabilities defined by Feeny and Wilcocks (1998), Ross et al. (1996), and Peppard et al. (2000) can be outsourced. However, many of these capabilities are made up of a complex combinations of elements, some of which may be considered for outsourcing or offshoring.

Although the article deals with the "post-offshoring" era, no distinction is made in the following between domestic outsourcing and offshore outsourcing except where it is obvious which one is being discussed.

In order to identify the specific IS activities that will need to be available within the organization in the post-offshoring environment, consider three broad criteria:

1. The activity inherently needs to be performed in-house, possibly in the same physical location as users and/or IS personnel, or a policy decision has been made that it would be too risky to outsource it (referred to subsequently as "required proximity" (RP)).
2. The activity is so important to the organization that the risks of outsourcing it are too great; the risks include losing the competence, having the competence appropriated by the vendor, and so forth (King & Malhotra, 2000).
3. The activity needs to be nurtured and further developed for the future.

The formal basis developed here makes use of the latter two criteria—importance and significance for the future in terms of the notions of "core competence" (CC) and "critical success factors" (CSFs) as they may apply to current activities or as activities may have the potential to be so designated in the future. Thus, the approach taken here is that core competence is indeed an important concept in determining the "outsourcability" of an activity, but it must be considered in a nuanced manner in conjunction with the CSF notion, and in terms of both the current situation and likely future circumstances.

Core Competencies

The notion of a core competency (CC) is fundamental to the resource-based view of the firm (Wernerfelt, 1984), but it is more widely discussed than it is understood (Quinn & Hilmer, 1994). Barthelemy and Adsit (2003) argue that core competencies are the resources and capabilities of the organization that are valuable, difficult to imitate,

and difficult to substitute. In particular, to qualify as a core competency, a strategic capability—one that is closely related to the strategy that the organization is pursuing—should have the following attributes (King, 1994, 1995a, 1995b):

- evolved slowly through collective learning and information sharing,
- incapable of being readily enhanced through additional investment,
- synergistic with other capabilities,
- not readily duplicable by others,
- not readily transferable to others, and
- plays a role in creating a competitive advantage.

Clearly, the conventional "CC" view of activity sourcing is that if an activity meets these criteria, it is a core competence and should not be outsourced. If it is a "commodity"—loosely speaking, something that does not meet any, or most, of the core competency criteria—it may be considered for outsourcing (Quinn & Hilmer, 1994; Hancox & Hackney, 2000; Insinga, 2000; King, 2001).

However, today's information technologies are so integrated into business processes that it may not be possible to clearly distinguish between what is core and what is not core (Earl, 1996). Most IS functions that might be separable from others, and thus have the potential to be outsourced, also typically have some elements that belong to the core and some that do not (Barthelemy & Adsit, 2003). Thus, it may not be a simple exercise to separate core from non-core activities when deciding about the 'outsourcability' of any IS activity. As a result, various studies have suggested that at times organizations may tend to outsource these broad, easily identifiable IT activities, part of which may happen to be a core competency (McLellan, Marcolin, & Beamish, 1995; Hancox & Hackney, 2000).

Critical Success Factors

Loosely speaking, critical success factors are those attributes that generally lead to success in a business. The notion is imprecise, but it has long been recognized that there are generally a small number of activities that, if exhibited or performed well, will create the opportunity for success (Rockart, 1979). Conversely, organizations that do not possess these attributes or perform these functions well will often not be successful.

More precisely, CFSs are necessary, but not sufficient, for success in a particular business context. Success at a CSF, or a set of CSFs, enables an enterprise or unit to "compete for the prize," but it does not guarantee that it will win it.

The CSF notion has been widely used in IS contexts, such as IS strategic planning (Pollalis & Grant, 1994; Bullen, 1995; Rockart & Earl, 1996). Here, it is applied in the context of IS sourcing.

Core Competencies and CSFs

Although the notions of core competencies and critical success factors emanate, respectively, from the resource-based and industrial economics views of business, they are not mutually exclusive in their application.

Although the former has an internal focus that the latter may not, they can coincide—for example, a core competence may be a CSF. Indeed, this may be thought of as an important goal of management: to create core competencies that are, or can be, critical success factors.

A Taxonomy for Classifying IS Activities

This leads to the following taxonomy for designating IS activities (adapted from King, 2001). An IS activity may be judgmentally assessed by management to be in one of five categories as shown in the left column of Table 1. (Other logi-

Table 1. Taxonomy for applying criteria

Categories	Recommended
#1. Not currently or potentially a core competence or a CSF	Consider for outsourcing/offshoring (O/O)
#2. Currently both a CSF and a core competence	Not potential candidates for O/O
#3. Currently a CSF and not currently a core competence	Mandatory development/investment
#4. Currently a core competence and a potential CSF	Retain in-house and improve
#5. Potentially a core competence and potentially a CSF	Monitor for possible future O/O

cal combinations may be generated, but are not meaningful in this context).

To these, we add the general criterion (above) based on inherent required proximity (RP). If an IS activity is judged to not be in the RP category and is judged to be in the first numbered category—not CC and not CSF, either currently or potentially—it should be considered for outsourcing or offshoring.

Similarly, IS activities that are evaluated to be in the second numbered category (currently both a CSF and a core competence) are unlikely to be candidates for outsourcing because of their critical importance. An organization would normally wish to preserve such activities, and continue to develop and refine them in ways that are probably best done in-house.

IS activities evaluated to be in the other categories present more complex situations. Activities in category #3 (currently a CSF and not currently a core competence) require mandatory development and investment in whatever manner is feasible and has the best chance of achieving the developmental objectives, since the viability of the IS enterprise will be importantly determined by such activities.

Activities in category #4 (currently a core competence and a potential CSF) need to be improved, refined, and scaled so that they may be "ready" for a future critical role in the enterprise. Usually, this is best done in-house.

The last category (#5) represents a diverse set of activities that may or may not be appropriately outsourced. Some may be "partnered" in order to obtain the complementary skills of a partner that are necessary for further development. Some may need to be developed to a scale that will permit future exploitation, usually through internal development. Still others may require only careful monitoring to determine their evolving potential.

Clearly, many of the evaluations that will result from applying these criteria are specific to each organization. Moreover, many of Feeny and Wilcock's (1998) core capabilities are decomposable into various elements, some of which may be outsourced even though they are part of a core capability.

Nonetheless, it is feasible to apply these criteria to specific IS activities and to draw conclusions that are likely to be appropriate for an organization. Such an evaluation presents a preliminary designation that may be an appropriate starting point for managerial evaluation of the costs and benefits of outsourcing each activity.

IS ACTIVITIES THAT WILL BECOME OF INCREASING IMPORTANCE IN THE POST-OFFSHORING ENVIROMENT

Based on the author's experience with outsourcing issues and with the practical application of the framework in more than 25 firms, a number of IS roles have been judged to be "non-outsourcable"

in the majority of firms. These are shown in Table 2 in three broad categories: "activities related to external relationships"; "activities related to the development," "customizing and implementation of systems"; and "business and IS strategic activities."

Activities Related to External Relationships

Seven activities fall into the category "Activities Related to External Relationships" as shown in Table 2: contract negotiation and management; relationship management; developing, negotiation, and implementing partnerships, strategic alliances, and joint ventures; vendor and partner assessment and selection; risk assessment and management; technology assessment and monitoring; and awareness of national cultures.

Contract Negotiation and Management

One of the things that the "early birds" in offshoring quickly realized was that when one offshores an activity, it needs to be replaced by another activity that will focus on developing, implementing, and controlling the contract.

Although the basic offshore contract will be drawn up by attorneys, they are usually not well-informed about IT and leaving the task to them is often problematic. For instance, IS people need to provide expertise on service-level benchmarks that should be put into the contract. IS people will also know which areas of activity are most dynamic and therefore most likely to require changes as the term of the contract progresses. This will permit the contract to be written in a manner that will accommodate reasonable change rather than, as has been the situation in some

Table 2. Common non-outsourcable IS activities

Activates Relating to External Relationships
• Contract Negotiation and Management
• Relationship Management
• Developing and Implementing Partnerships, Strategic Alliances, and Joint Ventures
• Vendor and Partner Assessment and Selection
• Risk Assessment and Management
• Technology Assessment and Monitoring
• Awareness of National Cultures
Activities Related to the Development, Customizing, and Implementation of Systems
• Systems Implementation and Integration
• Mission-Critical Systems Development and Testing
• Systems Testing
• Security
Business and IS Strategic Activities
• Business Process Redesign
• Integrated Business and IS Planning
• IS Personnel Development

instances, allowing changes to become so costly that the client believes that the vendor, who is in something of a monopoly position when changes are requested, is taking advantage of their position (King & Malhotra, 2000).

Relationship Management

Effective relationship management has been frequently shown to be related to outsourcing success. Many firms that thought they could offshore through a contract and then do little to monitor and manage the client-vendor relationship have been surprised with negative results from this style of outsourcing. In these instances, communications and coordination processes and their associated costs often were not given much attention.

For success in IS outsourcing, and particularly in offshoring, close attention must be paid to everything about the client-vendor relationship, from the criteria for selecting a vendor, to the frequent monitoring of progress, to the level of control exerted over the vendor, and to the level of trust that is developed in the client-vendor relationship. None of these things can be ignored or taken lightly, since all have been shown to be critical success factors for effective outsourcing (Cooper & Slagmulder, 2004; Choudhury & Sabherwal, 2003; Kim & Chung, 2003; Langfield-Smith & Smith, 2003; Goles, 2001; Lee & Kim, 1999; Das & Teng, 1998; Willcox & Kern, 1998; Klepper, 1995).

Developing, Negotiating, and Implementing Partnerships, Strategic Alliances, and Joint Ventures

Although many client-vendor relationships are referred to as "partnerships," few of them are much more than contractual business relationships. However, this is likely to change in the future as two or more organizations recognize that they have complementary skills and that for one organization to develop the entire range of skills that are necessary for success in an area of IS is excessively expensive. Whether these cooperative ventures are formatted as real partnerships, or strategic alliances or joint ventures, the identification of the need for cooperative effort, the negotiation of the "deal," and the implementation of an arrangement that provides benefits to all parties is a skill that IS departments increasingly need to develop.

Vendor and Partner Assessment and Selection

Since the days of the early computer era when outside vendors were used primarily for hardware, vendor assessment and selection have played a role in the IS organization. However, in this new era, it becomes of greater importance. The success or failure of the entire IS function can rest on the performance of a few vendors to which critical tasks have been outsourced. So, picking the "right" vendors becomes an IS critical success factor. Having a methodology and people who are skilled in applying it is key to success.

The same is true of potential partners and alliance participants. The IS organization must be aware of the array of potential partners and not merely respond to opportunities that are presented in a haphazard fashion. This involves identifying potential partners and their capabilities, assessing each for their "fit" with one's organization, and for likely new projects for which complementary skills may be required (Goles, 2001).

Risk Assessment and Management

Risk assessment and management will become a greater focus in vendor selection and in continuing relationship management. The risks that are involved in performing critical functions in third-world countries have not been fully recognized by most firms who have begun offshoring. Everything from political risk, to risks of natural disasters,

to the risks associated with marginal in-country communications infrastructures, needs to be taken into account and monitored. After all, India—the primary location for offshore vendors—almost became involved in a nuclear confrontation only a few years ago, and while international communications from India have improved dramatically, local communications and transportation infrastructures are often marginal. This leads to greater risk, especially when unplanned activities must be performed. Often, this will be addressed using "backup" sites, often in the Philippines, but this involves a new layer of complexity in the overall management process (Snow, Straub, Baskerville, & Stucke, 2006; Vijayan, 2004).

Technology Assessment and Monitoring

In an outsourcing/offshoring environment, a technology assessment capability must be maintained, or developed, by the outsourcing client since the vendor's objectives with regard to technology are not always consistent with those of the client. Many vendors wish to consolidate the work of many clients on their own legacy technology to achieve economies of scale and high returns. This may not always well serve specific clients, even if it meets their initial cost goals, since some clients might benefit greatly from greater accuracy, reduced cycle time, or a greater security level than is offered by the vendor (Orlikowski & Robey, 1991).

The monitoring of technological advances may, in fact, be performed outside the organization. But the CIO and other IS executives must be certain that they are aware of these developments, if only because it will enable them to anticipate technological changes that a vendor may be able to consider. The need to independently keep abreast of technology becomes apparent to every CIO shortly after he or she outsources operational computing systems. The outer office is no longer filled with vendor salespeople because the outsourcing client is no longer a potential customer for entire categories of hardware, software, and services. Only on recognizing that the outer office is no longer full do many IS executives realize how much important technological information they formerly obtained from salespeople. Those "pests waiting for an appointment" (as one IS executive put it) suddenly are then recognized for their value, and the IS manager realizes that he or she must do something to replace those old sources of information concerning technology.

The client must also independently assess evolving technology in order to maintain an awareness of potential service-level improvements that may become feasible through technological advances.

The client must continuously be aware of the offerings and capabilities of other offshore vendors as well. Even if a firm is involved in a long-term outsourcing contract, this is necessary. It also illustrates why negotiations and the terms of the contract are so important. No client should allow themselves to be truly "locked into" a long-term contract in which the vendor might attempt to provide, on a continuing basis, service levels that are less than those which other vendors offer. Contracts must provide for the continuous benchmarking of service levels against other providers (King & Malhotra, 2000).

Awareness of National Cultures

Another critical need in the post-offshoring era will be developing an understanding of relevant foreign cultures. For instance, the Indian culture is quite unique. Although the caste system has been officially outlawed, its vestiges remain strong. In many vendor nations, businesses and government agencies operate on the routine basis of bribery, hiring of relatives, unaccountability, and other-than-merit-based promotions. Of course, large Indian outsourcing vendors are much less traditional and more Westernized, but one need only look at the marriage system to recognize how much traditional cultural practices permeate all aspects and levels of Indian society.

Anyone who routinely deals with foreign vendors must recognize these and many other aspects of the national culture of the vendor, in order to understand the proposals of and responses given by the employees of foreign vendors.

Activities Related to the Development, Customizing, and Implementation of Systems

Four activities fall into this category as shown in Table 2: systems implementation and integration, mission-critical systems development and testing, systems testing, and security.

Systems Implementation and Integration

Systems implementation and integration is another area in which competence must be maintained and enhanced by an IT department that is going out of the programming and systems development "business" (which will increasingly be the norm). Increasingly, software will be developed by vendors, purchased by clients, and then customized and integrated with other internal and legacy systems. These implementation and integration processes may be aided by external consultants, but they often cannot be effectively done by outsiders; an internal capability that reflects a deep understanding of the business, its operations, goals, and priorities, is required.

Even when external consultants are used in these roles, the goal of the client must be to have their own personnel learn the skills that are necessary to perform these tasks with ever-less levels of outside help (Ko, Kirsch, & King, 2005).

Mission-Critical Systems Development and Testing

Some development and testing of mission-critical software/systems must be retained in-house since this is where the essence of one's information-based core competence resides. Most organizations have trade secrets and/or critical key processes embedded in their software and systems that they would not wish to be made available to outsiders.

Systems Testing

The testing of software is typically performed by the developer, but in the case of offshored development, clients should perform their own post-delivery testing.

Security

Sharing critical processes and software with vendors may increase risk to some degree. Of course, most vendors apply elaborate security systems and procedures. Indeed, in some cases, consultants have found that vendor security is better than client security. Nonetheless, the ultimate responsibility for the security of data, especially customer data, is with the client, so the necessary skills must be available in-house to assure adequate security.

Business and Strategic Activities

Three sets of activities fall into the category "Business and Strategic Activities" as shown in Table 2: business process redesign, integrated business and IS planning, and IS personnel development.

Business Process Redesign

Business processes cannot be effectively redesigned at a distance; direct contact between analysts and employees who are involved in operating the processes is required. Therefore, while many offshoring contracts relate to operating business processes, the analysis and modeling skills that are required for process redesign must reside in the organization's internal IS function (Sethi & King, 1998).

Integrated Business and IS Planning

Strategic IS planning is the link between the business strategy and the mission, strategy, goals, and architectures for IS in the organization. As such, this planning process requires in-depth understanding of the firm. It should (almost) never be outsourced or offshored.

IS strategic planning has been integrated into strategic business planning in many firms (Teo & King, 1997). This activity will need to be maintained, as no firm can ignore the potential role of IT in its future business strategy. When outsourcing takes place, top managers tend to presume that IT's role in the business is lessened and they may give less attention to it. IT people must understand business strategy and IT's role in it (even when large segments of traditional IT have been outsourced) and keep these issues in the mix of those treated in strategic business planning.

IS Personnel Development

IS employee development programs involving the IS jobs that are kept in-house as well as the "IS interface" jobs in the marketing, production, finance, and other "user" departments should also be retained in-house. Such programs may involve on-the-job training and/or job rotation through IS and business functional job assignments. In that way, career progressional plans can be developed involving the set of IS functions that are retained.

CONCLUSION

Offshoring and outsourcing must be treated as a major and central IS paradigm for determining the content and structure of the IS organization in the future. They can no longer be thought of as interesting appendages to basic IS.

The specific skills that are necessary for performing the activities that will remain in the IS portfolio in the new post-offshoring world of outsourcing—contract negotiation and management; relationship management; developing and implementing partnerships, strategic alliances, and joint ventures; vendor and partner assessment and selection; risk assessment and management; technology assessment and monitoring; awareness of national cultures; systems implementation and integration; mission-critical systems development and testing; systems testing; security; business process redesign; integrated business and IS planning; and IS personnel development—must be given central focus in the IT organization of the future. Many of these are typically not major foci of today's IS departments.

This means that IS departments will need to change in the post-offshoring environment. The focus for systems implementation and integration will need to shift from an internal orientation to one that addresses working in joint consultant-client teams. For instance, the typical ERP implementation project, in which joint teams work, often for several years, to customize and implement a vendor-supplied system to meet a firm's unique needs, is a good prototype for a process that will become increasingly common for an increasingly diverse set of vendor-supplied systems. Thus, inter-firm implementation processes will need to be more fully developed and studied (Ko et al., 2005).

This means that in this new post-offshoring era, IS people will need to understand negotiation techniques, contract law, and change management, and develop the "softer" skills that are required in partnering and developing trust between client and vendor. Strategic issues such as understanding the sort of benefits that may be expected from various kinds of potential "strategic alliances" with vendors will become essential. All of the key strategic management concepts—core competencies, critical success factors, and so forth—which

have been little known to IS professionals, must become familiar to them through revised curricula and training.

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ENDNOTE

[1] Feeny and Willcocks omit "project management" from their list although on the basis of their analysis, it should be there. Their reason is the somewhat idealistic notion that IT project management should be a business, not an IT, function.

This work was previously published in the Information Resources Management Journal, Vol. 21, Issue 1, edited by M. Khosrow-Pour, pp. 77-88, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 6
Is Information Systems (IS) Offshoring an Extension of IS Outsourcing?: Concept, Definition and Determinants[1]

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ABSTRACT

Some researchers focusing on information systems (IS) offshoring argue that results from previous studies on onshore IS outsourcing can be extended and applied to IS offshoring. However, others have the opinion that IS offshoring has its unique characteristics because of which, research made in onshore IS outsourcing cannot be extended without testing its applicability to the offshore context. This tension motivates the current research to examine whether determinants of IS offshoring are indeed the same as determinants of onshore IS outsourcing? If not, what are the implications? This chapter examines the role of business related firm level variables in determining the offshoring intensity of firms. The four business related variables that are analyzed in this study are: business size, business cost, business financial leverage, and business performance. The results indicate a significant relationship between business size and offshoring intensity, and also between business financial leverage and offshoring intensity. Based on the results, we analyze similarities and differences between traditional onshore IS outsourcing and IS offshoring. Implications and contributions arising out of this study are also discussed.

DOI: 10.4018/978-1-60566-962-5.ch006

INTRODUCTION

Arnett & Jones (1994) define information systems (IS) outsourcing as the transfer of IS assets, leases, and staff to outsourcing vendors. In other words, IS outsourcing can be viewed as the decision and process by which firms transfer various functional aspects of their IS to third party vendors. IS outsourcing has been a popular phenomenon since the time Kodak signed its first outsourcing deal in 1989 (Dibbern et al., 2004). But during this period, most of the outsourcing phenomenon was restricted within the borders of the country. In other words, most of the IS outsourcing work was onshore outsourcing. It is for this reason existing literature on IS outsourcing primarily focuses on onshore outsourcing. IS offshoring, which is an offshoot of IS outsourcing is a relatively new phenomenon. IS offshoring refers to the migration of all or part of the development, maintenance and delivery of IS services to a vendor in a country different from that of the client (Hirschheim et al., 2005). Developments in information and communication technologies (ICTs) in the last decade enabled effective and efficient delivery of digitized information across borders. Along with this, deregulations and removal of trade barriers spurred the development of IS offshoring. Firms now have convenient, real time access to the skills of knowledge workers from countries across the globe.

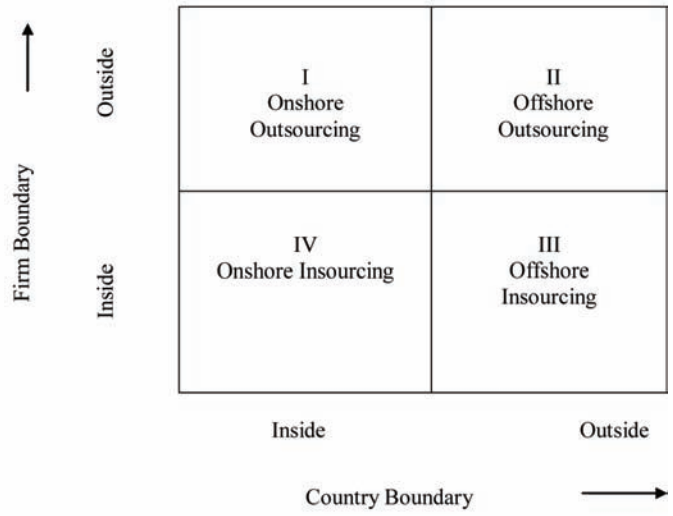
IS outsourcing and IS offshoring can be visualized as a decision which firms make regarding their strategy to cross the firm and the country boundaries. This can be represented in a 2X2 matrix (Figure 1). Simply speaking, the transcending of firm's boundary for IS functions can be described as IS outsourcing whereas crossing the nation's boundary for IS enabled functions can be viewed as IS offshoring. Figure 1 illustrates that offshoring (quadrants II and III) can be both outsourcing and insourcing, bringing out the fundamental difference between *definitions* of onshore outsourcing and offshoring. Offshoring projects might be outsourced, or alternatively they might be insourced to a subsidiary of the parent company.

In addition to the differences in definitions of outsourcing and offshoring, the firms' *motivations* for such actions might also be very divergent. Outsourcing normally enables firms to focus on their core competencies. Firms can strategically outsource those business processes which they do not intend to develop and nurture as a core competency (Slaughter & Ang, 1996). In contrast, in addition to focusing on core competencies, offshoring purports to strategically route the required services from those countries which offer comparable or better skills at a cheaper price. It makes it possible to extend enterprise boundaries to effectively access skills from distant places without physical movement of labor (Hirschheim et al., 2005; Rao, 2004). This phenomenon of taking jobs to the country of the skilled worker allows firms to tap the services of that segment of labor, which may otherwise be unwilling to move away physically, from their home country. Hence, firms not only have an incentive in terms of cost reduction but can also exercise a wider choice in terms of labor skills (Rao, 2004).

Another critical difference between onshore IS outsourcing and IS offshoring lies in the *modalities* for such arrangements. Unlike offshoring, it is relatively easier to monitor onshore outsourcing. There are two key reasons for this: the small physical distance, and the fact that both vendor and client are usually in the same time zones. In general, any function, which does not require physical monitoring and can be easily digitized for transmission through electronic means, is an offshore candidate. Thus, IS offshoring includes not only the firm's IS functions and processes but also its IS supported business processes (Trampel, 2004).

Though there has been a phenomenal increase in IS offshoring and the trend seems likely to continue (Gardner, 2006; Ribeiro 2006; Mao et al., 2008; King and Torkzadeh, 2008), scholarly

Figure 1. The boundaries of outsourcing and offshoring



deliberations on the subject are relatively sparse. Current research on IS offshoring focuses on three broad themes: offshoring relationship development and evolution (Carmel & Agarwal, 2002; Gefen & Carmel, 2008; Kaiser & Hawk, 2004; Khan et al., 2003; Nicholson & Sahay, 2004; Vivek et al., 2008), best practices, management and impact of offshoring (Aron et al., 2005; Kumar et al., 2008; Lacity & Fox, 2008; Levina & Vaast 2008; Mani et al., 2005; Rottman & Lacity, 2004) and the factors affecting growth of offshoring (Dutta & Roy, 2005; Mithas & Whitaker 2007, Whitaker et al., 2005). Though, there is a need for deeper understanding in all the three above mentioned areas, it is equally important to understand whether IS offshoring is just an extension of the onshore IS outsourcing phenomenon or is it fundamentally different. The research agenda is important in light of the fact that some researchers view IS offshoring as an extension of onshore IS outsourcing (Aron et al., 2005; Pfannenstein & Tsai, 2004) while others view IS offshoring as an altogether different phenomenon with its own unique contexts (Stack & Downing, 2005).

In this paper, we address two broad research questions. First, what are the important firm level business characteristics associated with the firms' offshoring intensity[2]? Second, is IS offshoring phenomenon different from onshore IS outsourcing in terms of the identified firm level characteristics? To answer these two broad questions, we identify some of the important firm level business characteristics from onshore IS outsourcing literature[3] and test their applicability in the offshoring scenario.

The rest of the paper is organized as follows. *First,* using literature on organization theory and onshore IS outsourcing, we identify business related antecedents that explains firms' offshoring intensity. *Next*, using firm level data, we test the hypotheses that we formulated. *Finally,* we discuss the results and conclusions of this study.

RESEARCH MODEL AND HYPOTHESES

Many recent studies on offshoring have investigated the host country characteristics contributing to firm's decision to offshore its business processes to that nation (Lewin & Furlong, 2005; Lewin et al., 2005; Rao, 2004). Surprisingly, there is little

empirical research exploring the firm level determinants of offshoring. In this paper, we develop a model for the firm level business related characteristics which determine its offshore intensity. We define offshoring intensity as the amount of production or service that has been transferred by the company from its parent country to a foreign destination.

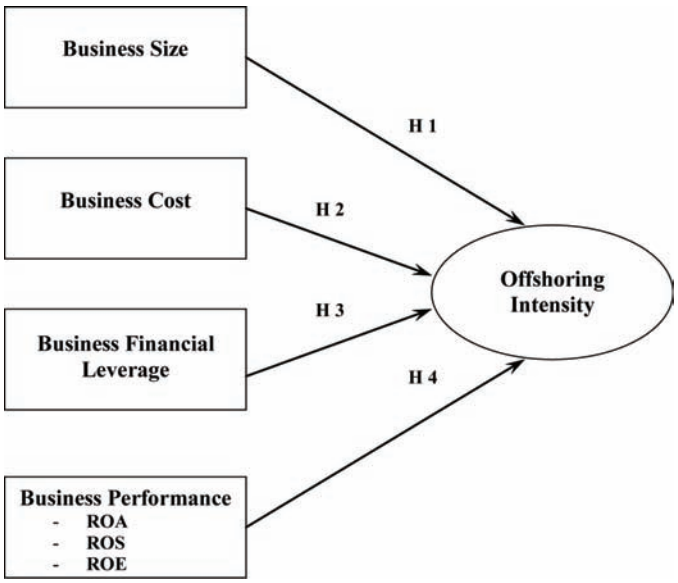
We posit that the firm level economic constructs *prior* to the offshoring event, guide not only the firms' decision to offshore but also determine the volume of its offshored activities. Economic constructs determining IS outsourcing activity have been conceptualized in the past literature (Loh & Venkatraman, 1992; Smith et al., 1998). Taking onshore IS outsourcing literature as the point of departure, we hypothesize in a similar way for IS offshoring. Past literature on determinants of IS offshoring has focused primarily on the binary decision of whether to offshore or not (Whitaker et al., 2005). In contrast to this, our study accounts for the differences in offshoring volumes across the firms.

Based on the theory of IS alignment, (Henderson & Venkatraman, 1992; Teo & King, 1997) we suggest the specific constructs of the business domain that should be aligned with the decision for IS offshoring. The theory of IS alignment suggests that the business structure of the organization should be aligned with the IS strategy for better performance (Chan et al., 1997). Consequently, offshoring, which can be a realized IS strategy should be aligned and dependent on the business structure of the firm. Thus, we posit that the firms' offshore intensity is dependent on the prior structural business characteristics of the firm, which includes business size, business cost, business financial leverage, and business performance [Return on Assets (ROA), Return on Sales (ROS), and Return on Equity (ROE)]. The research framework for this study is depicted in Figure 2.

Business Size

Past research finds organizational size, defined as total assets for the company, to be a major determinant of the firm's actions. Larger firms are more capable of taking advantage of the opportunities to enter new and promising markets than smaller

Figure 2. Research model: Business related determinants of offshoring intensity



firms (Damanpour, 1992; Haveman, 1993). The decision to offshore is a strategic decision for the firm (Faisal and Banwet, 2009). It involves a major shift in the firm's sourcing strategy and involves a lot of risk in terms of transferring a part of their value chain to a distant land with a different political, cultural, and social environment. Increased size of the organization gives it access to greater amount of resources, leading to its ability to better manage the risks associated with offshoring decisions (Aron et al., 2005; Swartz, 2004). Further, larger firms tend to have more experience in dealing with overseas partners than smaller firms and consequently may have greater confidence in managing offshore contracts. Thus, we hypothesize:

Hypothesis 1: The larger the size of the firm, the higher will be its offshoring intensity.

Business Cost

Business cost is the total cost directly associated with the actual production and co-ordination of firm's product line (Loh & Venkatraman, 1992). Firms in a competitive marketplace are exploring for ways to reduce their business costs to increase profitability (Porter, 1980). Firms having relatively high costs will consider the available options for bringing down their business cost. IS offshoring has been highlighted as a means to reduce the transaction costs for the firms (Ellram et al., 2008; Hirschheim et al., 2005; Khan et al., 2003; Pfannenstein & Tsai, 2004). Though traditional outsourcing reduces costs, offshoring purports to bring about greater reduction in costs because of significant cost arbitrage across national boundaries (Rao, 2004, Qu and Brocklehurst, 2003). For instance, cheap labor in India helps companies like American Express to reduce costs to the extent of millions of dollars (Agrawal et al., 2003). Thus, IS offshoring is one of the options which firms may exercise for reducing their business costs. This implies that firms that have relatively high business costs will be more inclined to follow this option. This argument is also supported by transaction cost theory, which suggests offshoring as an option to reduce the transaction costs (Carmel & Nicholson, 2005). Therefore, we hypothesize that a firm's prior business cost as one of the vital determinants of its offshoring intensity:

Hypothesis 2: The higher the prior business cost of a firm, the higher will be its offshoring intensity.

Business Financial Leverage

Financial leverage describes the degree to which a firm's business is utilizing borrowed money. Though financial leverage is not always bad, companies that are highly leveraged may risk bankruptcy if they are unable to service these debts. Financial leverage is one of the vital components describing a firm's business governance strategy (Loh & Venkatraman, 1992). When financial leverage is high, firms are burdened with high debt. Offshoring arrangements generally include significant initial contractual arrangements and financial risks with vendors because of transactions beyond national boundaries. Firms that are already burdened with high debts may not want to risk this new offshoring strategy. Prior research shows that firms with high financial leverage do not want to take risky initiatives, and are averse to new investments (Ertugrul et al., 2006; Gloy & Baker, 2002; Myers, 1977). Consequently, we hypothesize that firms with a high level of financial leverage will be less motivated to offshore their activities.

Hypothesis 3: The higher the prior financial leverage of a firm, the lower will be its offshoring intensity.

Business Performance

A vital component guiding the strategic decisions that firms make, is their business performance. When business performance of firms does not match the desired levels, they are on the look out for ways to improve their performance. With this objective in view, the changes incorporated in the firms may not only be related to improving direct operations but may also include changing strategic business mechanisms (Loh & Venkatraman, 1992; Smith et al., 1998). One of the changes in the business mechanisms that firms may consider is the use of IS offshoring to improve their business performance. The strategic change literature also suggests that firms having low performance will attempt a turnaround through strategic change (Barker & Duhame, 1997; Kimberly & Quinn, 1984; Zhang, 2006). The strategic change may be in terms of a change in the arrangement of firm's resource allocation to different functional areas (Ginsberg, 1988). Thus, firms having a low business performance may be motivated to use offshoring as a viable option. In our study, we use three measures of business performance: return on assets (ROA) return on sales (ROS) and return on equity (ROE) (Loh & Venkatraman, 1992; Smith et al., 1998; Zhang, 2006). Hence, we hypothesize that the prior level of business performance of a firm is associated with its offshoring intensity.

Hypothesis 4: The lower the prior business performance of a firm the higher will be its offshoring intensity.

Hypothesis 4a: The lower the prior ROA of a firm, the higher will be its offshoring intensity.

Hypothesis 4b: The lower the prior ROS of a firm, the higher will be its offshoring intensity.

Hypothesis 4c: The lower the prior ROE of a firm, the higher will be its offshoring intensity.

METHODOLOGY

Though the research questions in our study can be answered by using any of the two prevalent methodologies in IS studies, namely case study approach or questionnaire survey, we chose to use secondary data analysis for four important reasons. *First*, because of the political sensitivity surrounding offshoring, companies are unwilling to participate in surveys. Further, companies participating in surveys may not be willing to divulge details of their offshoring endeavors. *Second,* audited financial data provide a more objective evaluation of the firms' performance and other characteristics than the perception based data used in case studies and surveys. *Third,* secondary data research is easily reproducible thereby making it easier for other researchers to extend our work. *Fourth,* it gives an opportunity to deal with larger samples than when using in-depth case studies, which increases the generalizability of results. However, the limitation of using secondary data for research is that we have to depend on the information available in the databases.

For our research, the dependent variable is offshoring intensity. In this paper, we define offshoring intensity as the amount of production or service that has been transferred by the company from its parent country to a foreign destination. To operationalize the offshoring intensity, we use the number of jobs offshored by the company. Currently, there are relatively few secondary sources of information, which provide information related to offshoring firms in the US because of the political sensitivity of offshoring[4].

The data on the number of jobs offshored has been collected from TechsUnite[5] website database (TechsUnite, 2006). TechsUnite is a union for high-tech workers whose objective is to safeguard the interests of technical workers. The TechsUnite database tracks the number of jobs offshored by US companies from year 2000 onwards. Two researchers gathered data from this website database in early 2006 and the data collection took

about 5 weeks. The data collected indicates the cumulative total number of jobs offshored by each firm from the year 2000 till present. For testing the validity of the data collected from this website, we followed a two fold analysis. First, we corroborated and checked the names of the firms listed in the website, whether they really offshore or not. This we checked by comparing with the list of offshoring firms available at CNN website on "Exporting America"[6]. Second, we explored the various newspaper reports referenced as the source of offshoring information on the TechsUnite website for 10% of firms in the dataset and found the information to be generally correct and updated. Following this two step process gave us confidence about the validity of our dependent variable (offshore intensity). We included those firms in our analysis (a total of 152 firms) for which we could get the data on all the variables in our research model.

The firm related independent variables have been taken from Compustat for the year 2000, which is taken as the pre-event year[7]. There are two reasons for choosing the year 2000 as the pre-event base year for the firm level variables. First, the TechsUnite database recognizes the year 2000 as the critical year for the start of widespread offshoring phenomenon and tracks the number of jobs offshored by US companies from year 2000 onwards. Further, Reingold (2004) and Hirschheim et al. (2004) have stated that the current wave of offshoring took off from the Y2K phenomenon because of which foreign vendors got a chance to show their effectiveness in US market. Hence, the year 2000 marks the start of IT enabled offshoring. Studying firm characteristics before IS offshoring may provide us with an understanding of firm characteristics that precipitated the decision to offshore. For measuring the business size we take the total assets of that particular firm. This measure for size has been used by previous studies such as Ang & Cummings (1997), Loh & Venkatraman (1992), and Ang & Straub (1998). The business cost structure is indicated by the cost of goods sold (e.g. Loh & Venkatraman, 1992; Smith et al., 1998) and business financial leverage is directly reported from financial reports (e.g. Loh & Venkatraman, 1992). The business performance is indicated by the three measures of return on assets (ROA), return on sales (ROS) and return on equity (ROE) (e.g. Tam, 1998). In addition to the research variables, we controlled for the industry types in our analysis. To control for industry sector, we divided firms into five sectors based on the North American Industry Classification System (NAICS) and created a dummy for each sector: manufacturing and industrial, wholesale and retail trade, services, finance and real estate, and information (Table 1). These five sectors comprehensively cover almost all the manufacturing and service industries in the US. Such industry controls have been used in past outsourcing/offshoring studies such as Brynjolfsson et al. (1994) and Whitaker et al. (2005).

Table 1. Industry dummies created as control

Sl. No.	NAICS 2-digit codes	Description
1	11, 21, 22, 23, 31-33	Manufacturing and industrial
2	42, 44-45	Wholesale and retail trade
3	48-49, 54, 55, 56, 61, 62, 71, 72, 81, 92, 99	Services and others
4	51	Information
5	52, 53	Finance and real estate

RESULTS AND ANALYSIS

The descriptives and correlations among the various independent variables in our research framework are given in Table 2.

Serious multicollinearity problems may lead to deviation in the estimation of regression statistics (Stevens, 2002; Tebachnick & Fidell, 2001). From Table 1, we see that all correlations are below 0.80, signifying no serious problem of multicollinearity in our data (Gujarati, 2003). But we also see that one of the correlations, between ROA and ROS is rather high (> 0.70). Hence, to be confident that there is no serious problem of multicollinearity among the independent variables, we tested for multicollinearity among the independent variables by examining the Variance Inflation Factor (VIF); the results for which are given in Table 3.

VIF measures the impact of collinearity among the predictors in a regression model on the precision of estimation. In other words, it expresses the degree to which collinearity among the predictors degrades the precision of an estimate. Researchers suggest that multicollinearity is not a significant problem if the value of VIF is below 10 (Allison, 1999; Belsley et al., 1980; Stevens, 2002). In our case, the VIF values for all the independent variables are below 5 (Pedhazur, 1997), which is the conservative limit for multicollinearity. Hence, we conclude that there is no significant problem of multicollinearity among the independent variables in our study.

Table 4 presents the results of multiple hierarchical regression analysis where the dependent variable is offshoring intensity. In addition to the control variables, the independent variables were entered into the regression equation in four steps. After entering the industry dummies as controls, business size variable (assets) was entered in the first step, business cost variable (cost of goods

Table 2. Descriptives and correlations

	Variable	Mean	Std. Dev.	1	2	3	4	5	6
1	Offshoring Intensity	2106.82	3683.12	1.000					
2	Size (Assets)	58547.95	139159.41	0.250**	1.000				
3	Business Cost	11647.11	22557.52	0.223**	0.480**	1.000			
4	Financial Lev.	4.75	6.14	-0.015	0.630**	0.211**	1.000		
5	ROA	2.64	15.09	0.162	-0.008	0.058	-0.051	1.000	
6	ROS	15.42	34.70	0.078	0.222*	0.074	0.261**	0.717**	1.000
7	ROE	13.90	81.00	0.059	0.019	0.034	0.123	0.365**	0.231**

* p < 0.05 ; ** p < 0.01 (two-tailed test)

Table 3. VIF for independent variables

	Independent Variables	VIF
1	Size (Assets)	1.459
2	Business Cost	1.057
3	Financial Lev.	2.683
4	ROA	1.083
5	ROS	1.096
6	ROE	1.036

Dependent Variable: Offshoring Intensity

Table 4. Results of hierarchical regression analyses for offshoring intensity

Variables[8]	Model 1	Model 2	Model 3	Model 4
Step 1: Business Size				
Size (Assets)	0.370***	0.323**	0.372***	0.378***
Step 2: Business Cost Structure				
Business Cost		0.071	0.090	0.088
Step 3: Business Financial Leverage			-0.228*	-0.204†
Step 4: Business Performance				
ROA				0.219*
ROS				-0.113
ROE				0.036
R^2	0.227	0.231	0.247	0.273
Adjusted R^2	0.201	0.199	0.210	0.222
F	8.596***	7.243***	6.749***	5.308***
ΔR^2		0.004	0.016**	0.026

sold) was entered in the second step, business financial leverage variable was added in the third step and business performance variables (ROA, ROS, ROE) were added in the last step.

Results in Table 4, Model 1 indicates a strong support for hypothesis 1 (β=0.370, $p<0.001$). The results with size as a predictor of onshore IS outsourcing were generally found to be mixed by previous researchers. In some of the previous onshore IS outsourcing studies, size was not a significant predictor of outsourcing (e.g. Loh & Venkatraman, 1992) whereas some studies found size to be significant predictor of outsourcing, in the opposite direction (e.g. Ang and Straub, 1998). For IS offshoring, the results from our study, indicate that the size is a positive predictor of offshoring intensity. Further, we know that offshoring is more closely related to labor and employees, as the common rationale for offshoring is to derive labor cost arbitrage. Hence, we also tested the model using 'number of employees' as a measure of size, in place of total assets. The model using number of employees as an indicator of size was also significant. (β=0.399, $p<0.001$), providing robustness check for our results. Past studies like Ang & Cummings (1997), Loh & Venkatraman (1992), and Ang & Straub (1998) had considered only assets or sales as a measure of size.

This aspect of IS offshoring, having firm size as a significant positive predictor of offshoring intensity is different from onshore IS outsourcing. A plausible explanation for this difference is that larger firms have more resources and are able to better manage offshoring than smaller firms due to the larger scale of their business operations. Further, larger firms may have more experience and expertise in managing contracts with overseas firms. This international experience may influence the firms' propensity to offshore. Also, firms with a greater number of employees may have a greater incentive to reduce their manpower through offshoring. Size has been used as a control variable in many of the previous studies (e.g. Loh & Venkatraman, 1992). Entering 'size' (assets)

variable in the first step of multiple hierarchical regression also serves as a control for 'size' or 'total assets', thus making the subsequent results more meaningful.

The results in Table 4, Model 2 show that there is no association between business cost and offshoring intensity (β=0.071, ns). Hence, from the results, we conclude that hypothesis 2 is not supported. This result is different from that for onshore IS outsourcing. Previous studies have shown significant relationship between business cost and onshore IS outsourcing (Loh & Venkatraman, 1992; Smith et al., 1998). IS offshoring is a strategic decision to derive a long term cost reduction, but in the short run it might lead to an increase in cost. Highlighting this difference in short-term costs, and long-term costs of offshoring, Rost states, "The rather high costs of establishing the offshore scenario are present only during the first few projects. Thus, later projects will not be affected by these initial costs" (2006: 33). Hence, firms which have a high business cost may not be in a position to afford the initial high cost in an offshore decision. Since onshore IS outsourcing involves relatively less initial costs and immediate savings, firms which have a high business cost may resort to onshore outsourcing as found in Loh & Venkatraman (1992) study.

From the results in Table 4 (Model 3), we see that that the third step of the hierarchical regression model is significant. This implies that business financial leverage is significantly negatively associated with offshoring intensity as hypothesized (β=-0.228, $p<0.05$). Thus, hypothesis 3 is supported. This result is different from that for onshore IS outsourcing (Loh & Venkatraman, 1992; Smith et al., 1998). One plausible reason for this result is that firms with high financial leverage tend to be risk averse, hence tend to avoid offshoring.

In the last step (Table 4, Model 4), we added the business performance metrics of ROA, ROS and ROE. From the figures of R^2 change ($\Delta R^2 = 0.026$, ns) we see that in overall analysis, hypothesis 4 is not supported. Hence, business performance is not a significant predictor of offshoring intensity. On analyzing the individual hypotheses for the three performance variables, we find that relationship between ROA and offshoring intensity (hypothesis 2a) is not supported but is significant in the direction opposite to the hypothesized direction (β=0.219, $p<0.05$). For ROS, the relationship with offshoring intensity is not significant (β=-0.113, ns). For ROE, the relationship is also not significant (β=0.036, ns). One plausible reason for ROA being positively related to offshoring intensity may be fact that offshoring entails the firms to undertake inherent risks in the business processes (Aron et al., 2005; Swartz, 2004) and the firms' ability to do well in the ROA signifies efficient management of firm resources, which indirectly implies effective management of risk. Though the overall result of the relationship between business performance and offshoring intensity being not significant is similar to that for onshore IS outsourcing (Loh & Venkatraman, 1992; Smith et al., 1998), the significant relationship of ROA with offshoring intensity in the opposite direction provides interesting differences for the offshoring phenomenon. This result reiterates the importance of resource and risk management ability of firms as an important determinant for their offshoring intensity. The lack of support for hypothesis 2b and 2c may indicate that, as business performance is affected by many internal and external variables; its relationship with offshoring intensity is rather weak. Indeed, previous literature has shown a mix of firms which decide to offshore. Even firms which are doing well may be on a constant lookout for ways to reduce their costs even further, and consequently may resort to offshoring. A summary of results from this research are given in Table 5.

Table 6 gives a comparison of the results of past studies for the determinants of onshore IS outsourcing with the results from the present study on IS offshoring. From the discussion in the previous section and Table 6, we observe that the determinants of onshore outsourcing and

Table 5. Summary of results

Hypothesis	Result
Hypothesis 1: The larger the size of the firm, the higher will be its offshoring intensity.	Strongly Supported
Hypothesis 2: The higher the prior business cost of a firm the higher will be its offshoring intensity.	Not supported
Hypothesis 3: The higher the prior financial leverage of a firm, the lower will be its offshoring intensity.	Supported
Hypothesis 4: The lower the prior business performance of a firm the higher will be its offshoring intensity.	Not supported
Hypothesis 4a: The lower the prior ROA of a firm, the higher will be its offshoring intensity.	Not supported (Significant in opposite direction)
Hypothesis 4b: The lower the prior ROS of a firm, the higher will be its offshoring intensity.	Not supported
Hypothesis 4c: The lower the prior ROE of a firm, the higher will be its offshoring intensity.	Not supported

offshoring are different in a number of important aspects, thus emphasizing the point for studying IS offshoring as a phenomenon different from onshore IS outsourcing.

LIMITATIONS

Though this research analyzes some of the important questions related to IS offshoring, there are a few limitations which raises various issues that can be explored by future research. We do not address the role of firm's IS competence in determining its offshoring intensity. Future research can further broach on this subject. The current research is also limited by the fact that it only explores conditions under which firms offshore, but does not suggest whether those conditions are ameliorated after offshoring. In other words, did offshoring have the intended impact? This aspect also needs to be investigated in future research. Further, owing to the dynamic nature of offshoring, it would be interesting to know, if determinants of offshoring have evolved over time. Future research needs to be done with longitudinal data to investigate this phenomenon further.

CONTRIBUTIONS AND CONCLUSION

Despite these limitations, our research offers the following important contributions that have im-

Table 6. Comparison of business related determinants of onshore outsourcing and offshoring[9]

Outsourcing Constructs	References	Results	Offshoring Construct	Results (this study)
Cost structure (+)	Loh and Venkatraman (1992)	Supported	Business cost (+)	Not supported
Cost efficiency (+)	Smith et al. (1998)	Supported		
Financial performance (-)	Loh and Venkatraman (1992)	Not supported	Financial performance (-)	Not supported
Financial leverage (+)	Loh and Venkatraman (1992)	Not supported	Financial leverage (-)	Supported
Firm size (assets) (+)	Ang and Cummings (1997)	Supported	Firm size (assets) (+)	Supported
Firm size (assets) (-)	Ang and Straub (1998)	Supported		
Firm size (assets and sales) (+)	Loh and Venkatraman (1992)	Not supported		

plications for practitioners and academics. *First,* our study analyzes the role of antecedent business related variables as determinants of firm's decision to offshore. Past studies aiming to understand the antecedents of offshoring have used the decision to offshore as a binary variable (either a yes or a no) (Whitaker et al., 2005). We go beyond this, to understand the role of business related variables in determining the *intensity* of offshoring. This is analogous to research on IS adoption where some researchers (e.g. Rai & Patnayakuni, 1996) advocate that there might be different degrees of adoption rather than just conceptualizing adoption as a dichotomous variable. *Second,* we analyze the similarities and differences in the determinants of offshoring from that of the traditional onshore IS outsourcing phenomenon. Our research points out important differences between the two, and emphasizes the importance of treating the two business arrangements as related, but different phenomena. This has important implications for firms resorting to onshore outsourcing as well as offshoring simultaneously. It also has important implications for researchers as it provides further avenues for research to determine the nature and reason for these differences. *Third,* two of the important differences between offshoring and traditional onshore IS outsourcing emerging from this research are the importance of the firm size and return on assets (ROA) in determining the decision to offshore. Larger firms generally have deeper pockets in terms of greater amount of resources (hence more risk taking ability) and firms with a higher ROA generally have better ability to manage risks. Thus, these two determinants for offshoring intensity (size and ROA) suggest that offshoring firms not only have a *greater risk taking ability* but also a *better risk management ability.* Thus, risk taking and managing ability emerges as a major determinant for the offshoring decision. Future research can explore this finding in greater detail. *Fourth,* the two other differences between the determinants of onshore IS outsourcing and IS offshoring brought out from this study concern the aspects of prior business cost. IS offshoring intensity is not associated with a high prior business cost, but is significantly associated with low prior financial leverage. Both these results for offshoring indicate the *long term strategic perspective* taken by the firms deciding to offshore. Since the decision to offshore is not dependent on high prior business cost, these firms are not looking for immediate cost reduction rather they are looking for long term stable cost reduction (Rost, 2006). At the same time, firms which have low debts (low financial leverage) can afford to take risks to go for offshoring. It is important for firms to realize that offshoring is a long term decision having strategic business implications and firms should not be looking for short term gains from offshoring contracts. *Fifth,* the research assists offshoring vendors to target those companies with the identified firm characteristics as possible offshoring clients.

The IS offshoring phenomenon is increasingly gaining importance in the industry. Thus, it is important that we answer the fundamental question: What makes firms offshore? Hence, understanding the determinants of offshoring is vital. In addition to understanding these determinants, we need to know how these determinants differ from determinants of traditional onshore IS outsourcing. Such knowledge will lead to a better appreciation of the offshoring phenomenon and may help managers to enhance firm performance. If offshoring is different from traditional onshore IS outsourcing, offshoring firms resorting to a strategy similar to that for IS outsourcing may require refocusing their agenda, so as to address the particular issues associated with the implementation of offshore contracts. Through this study on IS offshoring, we understand the role of firm level business related variables (business size, business cost, business financial leverage, and business performance) in determining the intensity of offshoring activity. We also analyze how these are similar or different from previous research on onshore IS outsourcing activity. The results from this research suggest that

offshoring is different from onshore outsourcing and needs greater academic as well as practitioner attention.

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ENDNOTES

1 An earlier version of this paper appeared as Srivastava, S.C., Teo, T.S.H. & Mohapatra, P.S. 2008. Business Related Determinants of Offshoring Intensity, *Information Resources Management Journal,* 21(1): 44-58.

2 Offshoring intensity is defined as the amount of production or service that has been transferred by the company from its parent country to a foreign destination and is operationalized by the number of jobs offshored by that company.

3 IS outsourcing literature generally refers to the context of *onshore* IS outsourcing. The distinction from offshore outsourcing became noteworthy only after the growth of information and technological capabilities that could facilitate offshore outsourcing.

[4] The US press and media are replete with articles debating the offshoring activity, and offshoring was a hot topic discussed in Presidential debates in 2004 and 2008 (Metters and Verma, 2008). Public opinions against offshoring is based on many perceptions, including perceived job losses and damage to domestic industries (Durvasula and Lysonski, 2009).

[5] Techsunite.org (http://www.TechsUnite.org) is the nationally-oriented web site of WashTech/CWA, the nation's leading union for high-tech workers. TechsUnite is a project of the Communications Workers of America, AFL-CIO, in collaboration with the following site partners, supporters and stakeholders: Alliance@IBM, Carol-Trevelyan Strategy Group (CTSG), Center on Wisconsin Strategy, CWA National Education and Training Trust, Washington Alliance of Technology Workers, and Working Today.

[6] http://www.cnn.com/CNN/Programs/lou.dobbs.tonight/popups/exporting.america/content.html

[7] Year after which offshoring phenomenon became widely prevalent in business

[8] We control for industry segment by creating five industry dummies as per NAICS classification (Table 1)

[†] $p < .1$; * $p < .05$; ** $p < .01$; *** $p < .001$ (one-tailed test); N = 152

[9] Adapted from Dibbern et al.2004

Chapter 7
Hybrid Offshoring:
Composite Personae and Evolving Collaboration Technologies

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ABSTRACT

Inspired by round-the-clock manufacturing, the 24-Hour Knowledge Factory endeavors to transform the production of software and other intangibles into a process of continuous development. While the concept of offshore software development is well established, few enterprises are currently able to develop the same code artifacts around the clock. We discuss the benefits of applying the 24-Hour Knowledge Factory to software development. We also present a representative scenario highlighting the problems of asynchronous communication in current offshore software development practices. Further, we introduce the notion of composite persona as a potential collaboration model within the 24-Hour Knowledge Factory and explain its ability to mitigate problems arising from communicating across cultures, languages, and time zones. Finally, we present a suite of new collaboration tools and techniques that are being developed specifically for use by composite personae in the 24-Hour Knowledge Factory.

INTRODUCTION

Inspired by the paradigm of round-the-clock manufacturing, the concept of 24-Hour Knowledge Factory endeavors to transform the production of intellectual property and intangibles into a process of continuous development (Gupta & Seshasai, 2007). More specifically, we envision a 24-Hour Knowledge Factory as an enterprise composed of multiple sites that are evenly distributed around the globe. As the sun sets on one site, it rises on another; like an ongoing relay race chasing the sun, the day's work is handed off from the closing site to the opening site.

The benefits of implementing a software development enterprise as a 24-Hour Knowledge Factory are several. We expect to realize gains from significant compression in development schedules, faster turnaround time for localization and customization of existing products, and bug fixes and critical security patches released with greater celerity. However, we also admit that the challenges of establishing a 24-Hour Knowledge Factory are significant. More specifically, we anticipate technical challenges arising from asynchronous communication, which will likely be exacerbated by cultural and linguistic differences (Seshasai & Gupta, 2007). Non-technical challenges may grow from political and legal circumstances, and from difficulties in managing and operating in such a nontraditional business environment.

In this article, we discuss the current state of offshored and globalized software development and some of the underlying difficulties. Next, we introduce the concept of the composite persona. Finally, we discuss evolving collaboration technologies that support the concept of composite personae in the context of hybrid offshoring.

GLOBAL SOFTWARE DEVELOPMENT

Software development projects that involve multiple international sites have been a reality since the 1960s (Carmel, 1999, p. 17). However, those early efforts were relatively rare compared to the near ubiquity of contemporary global software development (GSD) (Gupta, 2007). By the year 2000, 200 of the Fortune 500 companies relied upon global software development teams or outsourced development to firms that use them (NASSCOM, 2000).

Our vision for the 24-Hour Knowledge Factory for software development is not synonymous with currently accepted GSD methods. Rather, the 24-Hour Knowledge Factory is a special case of GSD that has several unique properties while inheriting most of the problems of GSD. Subsequently, we present a brief survey of contemporary GSD methods to better define the problem of software development in the 24-Hour Knowledge Factory.

Convention and Practice

Engineering is the process of designing systems to solve problems. The activity of software engineering produces software systems to solve problems. Like nearly all engineering disciplines, software engineering advocates that large problems be recursively decomposed into smaller sub-problems and their corresponding sub-system solutions. Decomposition proceeds recursively until the problem-solution pair is tractable in both understanding the sub-problem and the resulting complexity of the sub-system. In modern parlance, the ultimate result of decomposition is a set of modules and classes (expressed in an object-oriented language such as Smalltalk, C++, or Java), where each class can be more-or-less completely understood by one person.

These modules and classes are then assigned to developers who then own that artifact throughout the process of coding, unit testing, and possibly even maintenance. Each module or class has one owner, and only that individual may alter that artifact. Ownership confers the benefits of accountability for defects and preserves the continuity of the actual state of the artifact with the expected state of the artifact. Although a few software practices advocate otherwise, single ownership is the most generally accepted practice (Nordberg, 2003).

Ideally, sub-problems can be solved in complete isolation from lateral, sibling sub-problems. This allows for sub-systems to be viewed as *black boxes*: entities that have defined behavior and state, and whose inner workings are not visible to those outside of its development. With respect to coding and implementing, black boxes confer autonomy on the developer and permit development to proceed concurrently. If the problem was initially well defined, with complete knowledge of the domain of interest, and there is little change in the environment in which the software is to be deployed, then there should be little lateral communication between implementers of sub-systems. It is, most unfortunately, a rare case where these perfect conditions exist.

More typical is the case where, during the process of development, the problem is more complex than what was originally believed or conditions external to the project have changed. Either case causes alteration to the requirements which were used to produce the original design. Software, like a machine, requires that all of its components operate in harmony. Changes in the requirements and subsequent behavior of one sub-system propagate to those sub-systems with which it interacts, creating a rippling wave of secondary changes in those sub-systems, and so on.

The result of this phenomenon is a need for lateral communication between sub-system developers. In the context of GSD, lateral communication between sites often introduces delays, costs, and risks. As an illustration, consider the following fictional, yet representative, scenario.

A Typical Scenario in GSD

Yankee Software, Inc. is developing a new client-server application for clinical use by physicians in hospitals and other high-tech treatment centers. The new software is to be marketed internationally and must conform to local laws and standards. After thoroughly studying the problem, consulting many potential customers, the architects at Yankee Software develop a design and subsequently produce the models and documents that will be used by the programmers to implement the software.

In order to reduce coding costs and leverage significant experience and talent with coding for highly reliable networking software, Yankee Software is partnering with Muscovite Technologies in Russia. Yankee Software will develop the end user client, workflow engine, and validating rules, while Muscovite Technologies will develop the database, cache, and network server system. After the design phase and an initial kick-off meeting where both parties sign off on the design, coding begins.

The designers had anticipated several risks; key among these known risks was the vulnerability of the validating rules. These rules localize the software for operation in the various legal and standards frameworks in which each potential customer must operate. During development, this risk becomes realized in a change in record keeping standards in the United Kingdom's National Health Service. The change is significant enough to necessitate an adjustment in both validating rules and database structure. At this stage of the project, such a change will be quite costly in terms of redesign and coding. However, the market potential for the NHS is second only to the domestic U.S. market, and Yankee Software does not want to lose such an opportunity. Consequently, the

requirements are altered and parts of the system undergo redesign.

Several weeks later, Kathy, a programmer for Yankee Software in San Jose (California, USA) comes across an ambiguous condition in the specification for the software. It appears to her that there is a conflict in how the server handles errors. The prior documentation, before the NHS redesign, and the posterior documentation issued after the redesign disagree in several cases. Since the affected server component has already been coded, Kathy decided to contact the owner of that code. Following is an outline of the (fictional) discussion that these two developers might have. (Note that Moscow is 11 hours ahead of San Jose.)

On Day 1, Kathy discovers the ambiguity. She consults with a few co-workers at her site in San Jose and decides to e-mail the owner of the component, a developer named Feodor in Moscow, Russia. Kathy puts further development of her component on hold and continues with other work.

When Feodor logs in to read his e-mail at the beginning of Day 2, he sees the message from Kathy asking for clarification. The problem is complex, English is Feodor's second or perhaps even third language, and Kathy' writing style is not very expressive. Feodor is confused as to the exact meaning of Kathy' query and sends a reply asking for more details and further clarification.

Later in Day 2, after Feodor has signed off, Kathy logs in and reads Feodor's reply. She takes a few minutes to think of a better way of explaining what she had found and what she was asking, citing the specific sections of the documents in conflict and including a fragment of the code. She sends the improved, clarifying question to Feodor.

It is Day 3 and Feodor logs in to find Kathy's question easier to understand. Feodor believes he understands the problem and takes a few minutes to compose the reply. Later that same day, Kathy reads Feodor's response and believes that she understands Feodor's answer. However, Feodor accidentally replied with a double-negative, and since this potential defect may be harmful to their market in the UK, Kathy composes another question for Feodor to verify his answer.

On Day 4, Feodor logs in to read his e-mail. He shakes his head for a moment, amused at his own mistake and writes a response agreeing with Kathy's statement and verifying his own prior e-mail. After the sun has set in Moscow, Kathy reads Feodor's response and alters the client-side code that she is developing to be in harmony with the server-side code that Feodor has already written.

In the preceding story, Kathy and Feodor, separated by an 11-hour time zone difference and speaking across languages and cultures, spent four days solving a problem. Had the two developers been co-located, this problem would likely have been solved within a few hours.

COMPOSITE PERSONAE

The pressure to collaborate has increased with the use of offshoring, in which developers need to be addressed at different locations, according to Booch and Brown (2003). About 70% of a software engineer's time is spent on collaborative activities (Vessey & Sravanapudi, 1995). As demonstrated above, this need for communication can confound software development when the distributed teams span multiple cultures, languages, and time zones.

As a mechanism to correct for asynchronous communication lag and ambiguity introduced by cultural and linguistic differences, we introduce the notion of *composite persona*. A composite persona (CP) is a highly cohesive micro-team that, like a corporation, has simultaneous properties of both individual and collective natures. That is, a composite persona to an external observer has a unique name and acts as a singular entity, even though it is the composition of several individuals.

With respect to CPs, each site is a mirror of the other, having exactly the same CPs as each other site. (Note that this does not imply that each site has the same number of staff, as one developer may belong to more than one CP.) As the world turns and sites turn on and turn off, each CP remains active, but the "driver" of each CP changes with each site.

Using CPs, development proceeds in the same manner as in a more traditional, local process. Problems are decomposed into modules and classes as they are when only single developers are assumed. However, when modules and classes are assigned ownership, the owner of each artifact is no longer an individual developer but rather a CP. Similarly, in the process of conflict resolution, discussion, and debate, each CP contributes as a single entity.

In the following subsection, we present three scenarios that exemplify what we anticipate will be common interactions within a CP and between CPs.

A Composite Personae Scenario

For the purposes of illustration, we assume three development sites: Tucson (USA), Wroclaw (Poland), and Sydney (Australia). We will focus on two CPs: CP Mercury and CP Minerva. CP Mercury will be composed of Tom (USA), Grzegorz (Poland), and Molly (Australia). CP Minerva is staffed by Rachel (USA), Sylwester (Poland), and Jack (Australia).

Furthermore, our scenario will take place in early November. Tucson is at GMT-7, while Wroclaw is at GMT+1. November is in Austral Summer. When the residents of Sydney set their clocks ahead at the end of October, they are at GMT+11.

Forward Communication and Handoff

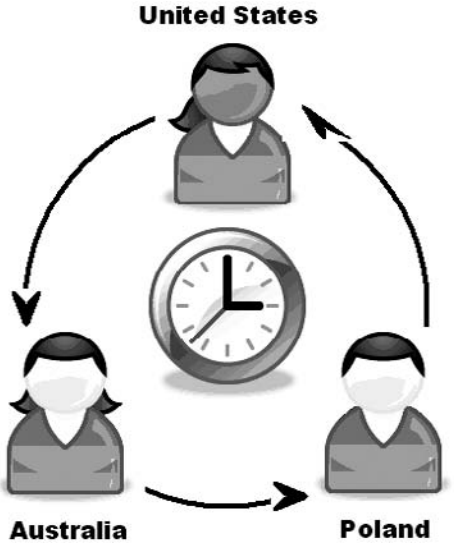
The most basic operation in the context of CPs is the handoff, depicted in Figure 1. This occurs at the change of every shift, when the current driver signs off and the new driver, as the next site turns on, signs on and takes over responsibility for the CP. Our prototype handoff procedure is inspired by the daily stand-up meeting used in the Scrum agile process (Schwaber & Beedle, 2002). Scrum daily stand-up meetings, for co-located developers, are done first thing in the morning. All attending are asked to briefly summarize what they accomplished the previous workday, what problems they encountered, and what they expect to accomplish today. We think this to be a very succinct set of questions to be used as a basis for the handoff from one driver to the next. Following is brief story that demonstrates a handoff.

It is nearly 15:35 GMT, 25 minutes before Grzegorz's shift ends at his office in Wroclaw. He looks up at the clock and decides to wrap up his work for the handoff to Tom. Grzegorz opens up the handoff tool and begins filling in template forms and following a scripted workflow.

At 15:50 GMT, Grzegorz completes the last of the handoff forms and officially ends his workday.

At 15:55 GMT, Tom signs on and becomes the driver for CP Mercury. He takes several minutes

Figure 1. Handoff



to read what Grzegorz accomplished and finds that Gzegorz has found what he thinks is a bug in a class owned by CP Minerva. He recommends to Tom that he query CP Minerva and continue working on a couple of troublesome methods of a class owned by CP Mercury. Tom agrees and sets about his day, accordingly.

At 22:05 GMT, Tom gets an instant message from Molly. It is just after 9:00 a.m. DST in Sydney and she is beginning her day. She and Tom chat online to divide up the work recommended by Grzegorz. Tom is still driving CP Mercury and has checkout priority for any code artifacts owned by CP Mercury.

At 23:30 GMT, Tom walks through his handoff report and submits it at 23:50 GMT. Since there are still a few minutes of overlap, he sends an instant message to Molly. She sends an instant message back to Tom informing him that his handoff report is understood and wishes him a good evening. At 23:57 GMT, Tom signs off and Molly becomes the driver for CP Mercury.

The hand-off process transfers knowledge from the driver signing off to the driver signing on. This transfer is unidirectional from past to present and forms the forward dimension in the two-dimensional communications that are possible with CPs.

Resolving a Simple Problem with Lateral Communication

Many simple problems can be resolved by real-time communication between drivers. In co-located software development, these small problems are often resolved by a phone call or a quick chat over a cup of coffee. There is no appropriate analog in GSD, where even simple problems can result in significant delay as rounds of conversation ensue over e-mail (Herbsleb, Mockus, Finholt, & Grinter, 2003). Even when developers work off-hours to make real-time contact with other sites, the communication channels available carry less information than co-located face-to-face interaction.

Consider the following example from Figure 2: At 21:10 GMT, Tom, driving for CP Mercury, gets an instant message from Rachel. Rachel is currently driving CP Minerva. One of the components owned by CP Minerva is using a component owned by CP Mercury. Rachel asks Tom for an example of how to use a certain feature of CP Mercury's component. Tom thinks about it for a moment and then sends a reply with a code fragment for her to study. She thanks Tom for the example.

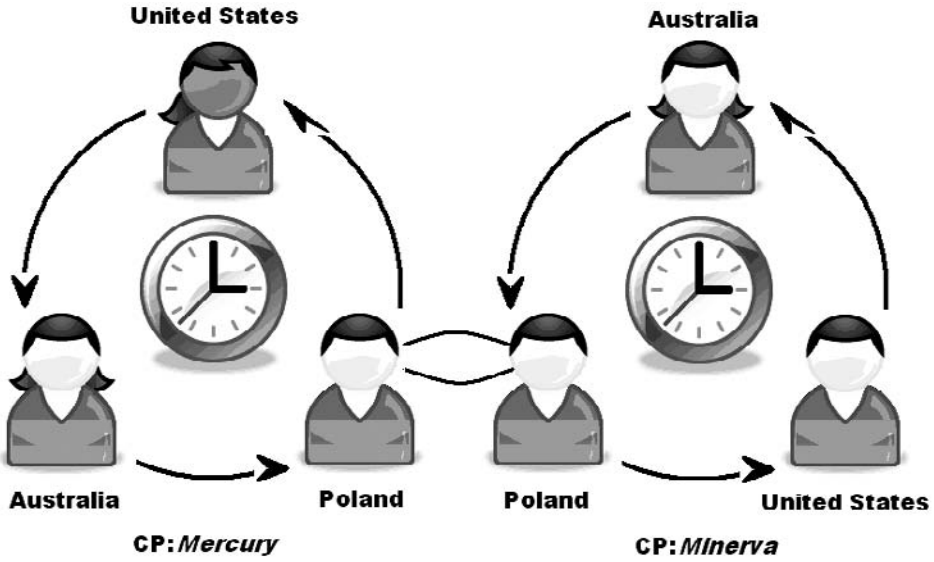
This form of communication is lateral between CPs and is orthogonal to the forward communication dimension. The third communication pattern is established when information is flowing along both dimensions.

Resolving a Complex Problem Using Both Communication Dimensions

For the purpose of clarification, we will define a complex problem as a problem that involves two or more CPs and cannot be solved within a single working shift. This problem must therefore be handed off from one driver to the next. A complex problem that can be handled completely internal to the CP can be resolved in much the same way as development. (Writing code is somewhat equivalent to solving a long and complicated problem.)

At 13:10 GMT, Grzegorz reads an e-mail sent to CP Mercury about a test that had failed and indicating a fault in a component owned by CP Mercury. Fortunately, the message contained a trace of the code that created the fault as well as the parameters of the test. Grzegorz finds that the problem seems to arise only in test cases where the component owned by CP Mercury is used by a component owned by CP Minerva. Grzegorz contacts Sylwester via instant messenger and they begin the work of tracking down the bug. At the end of their shift, each of them completes

Figure 2. Lateral communication



their respective sign-off procedures and ends the day hoping that Tom and Rachel will be able to find the solution.

Tom and Rachel sign in within a few minutes of each other. Tom, seeing that Rachel is also at work, sends her an instant message, and they agree to continue working on the problem. Each takes a few minutes to catch up on the notes from their counterparts. Grzegorz and Sylwester have done most of the work, and it does not take much longer before Tom and Rachel find the source of the fault and have it corrected.

Benefits of CPs in the 24-Hour Knowledge Factory

We anticipate several benefits of applying the composite personae strategy in the context of the 24-hour Knowledge Factory.

Smooth Transition

The process of decomposition, design, and assigning ownership is essentially the same whether development is done by individuals or by CPs. The introduction of CPs augments the body of engineering knowledge and does not deprecate anything. Furthermore, during migration from current practices to one that incorporates CPs, an enterprise is able to mix and match as needed. Some artifacts may be owned by individuals, others by CPs.

Increased Trust

Trust is notoriously difficult to establish in GSD projects (Handy, 1995; McDonough, Kahn, & Barczak, 2001) but essential for success (Sarker et. al., 2001). Humans in collective efforts work best in teams where each member of the team shares the common goal of the team, and members trust the intentions and efforts of each other member. Here we are looking for the jelled team described by DeMarco and Lister (1987). As group size increases and the frequency and expressiveness of communication decreases, trust within the team suffers greatly (Carmel & Bird, 1997).

CPs are very small, typically comprising of three or four individuals, and trust is easier to establish between these few members than it

would be within a larger group. Although most communication will be done asynchronously, communication between members of CPs will be frequent and informative. While asynchronous communication is much less expressive than synchronous communication (Sproull & Kiesler, 1991), we expect that such persistent, frequent communication will lead to greater trust than is common in contemporary GSD projects (Jarvenpaa, Knoll, & Leidner, 1998; Javenpaa & Leidner, 1999; Maznevski & Chudoba, 2001).

Convergence

At this conceptual stage of our development of the CP, we believe that communicating the changes made by each driver to the other members will require less costly communication than associated with current global software development practices. We expect that after working on the same artifact for some time, the knowledge held individually by each member of a CP will converge. That is, we expect that developers within the same CP will, after some warm-up period, have essentially the same concept of the problem domain, solution options, and the utility space of those options. For a given question about some code artifact, each member of the CP that owns the artifact is likely to give very similar answers. Consequently, between members of a CP, communicating the purpose of incremental changes and the overall state of the artifact will become increasingly efficient as their mutually shared experience grows with time.

Here we can draw upon the experience of Extreme Programming (XP), from which our CPs are inspired (Beck, 1998, 1999). XP advocates collective ownership of code, allowing anyone in the project to alter any artifact. This is made possible by creating mutual experience and shared knowledge through *pair programming*: the process of having two people work on the same artifact, simultaneously, using the same workspace. While XP is not without controversy, especially for larger projects and distributed development, we believe our CP method to be an especially useful balance for the 24-Hour Knowledge Factory. CPs prevent surprises and preserve accountability as per the single ownership model, yet enable many other collective ownership benefits that are discussed here.

24-Hour Access to Owner

The practice of single ownership of code artifacts works well when all development is done in the same time zone. However, for sites that have very little or no overlap in work schedules, the single ownership model becomes a hindrance. For instance, in the coding phase of the linear development model, bug fixes are typically routed through the owner of the artifact. In this way, the owning programmer is knowledgeable of any changes made to the artifact and understands how those changes alter the behavior of the artifact.

If we assume only one owner and three non-overlapping development sites, then 16 of the 24 work hours in a day are done by centers which do not have direct, synchronous communication with the owner. Necessary changes must wait until the owner's site turns on, creating a bottleneck for related work in the other two centers. Accordingly, by our method of assigning ownership to CPs, each piece of code artifact can be modified at almost any time.

Higher Truck Number

So-called from the imagined worst-case scenario where a project member gets struck by a runaway truck, the *truck number* of a project is an amusing but useful metric for expressing vulnerability to the loss of critical talent. The collective code ownership model and consequent degree of redundancy of knowledge about any given artifact increases the truck number of the project and decreases development risks introduced by the

possibility of losing critical talent and specialized knowledge (Nordberg, 2003).

With three-member CPs, a CP could lose a single member and the enterprise will still retain two people that have intimate knowledge over the artifacts owned by that CP. While productivity may decrease for the period that the CP remains understaffed, the project survives. When a new member is brought into the CP, the new member has the project artifacts and notes from the previous developer; in addition, (s)he has direct and frequent access to the two remaining members in the CP.

This feature may be particularly important when including labor from nations where worker turnover is high. Indeed, some recent observations imply that high employee turnover in offshore companies often is a significant risk in contemporary offshoring strategies (Carmel & Agarwal, 2002; Lewin & Peters, 2006; Offshoring Times, 2006). This makes the higher truck number inherent to CPs to be a major advantage over current offshore development practices.

Localizing Lateral Communication

In a case study done by Herbsleb et al. (2003), little difference was found in the number of lateral communication delays incurred by a local development project and a GSD project. However, the GSD project experienced longer delays. In this particular study, the mean delay time for the locally developed project was 0.9 days, while the mean delay time for the GSD project was 2.4 days. Our own work on studying communication in technical USENET conversations (Denny, 2007) suggests an average delay of between two and five days. With each CP represented at each site, lateral communication is now mostly local. Consider a question by CP Minerva about a code artifact owned by CP Mercury. If the Tucson site is on, then Tom will be answering a question by someone else co-located at his site. If Tucson is off and Sydney is on, the Australian driver for CP Minerva will be asking Molly instead. Further, since each site is relatively mono-cultural (with respect to the entire enterprise), lateral communication will be nearly free of ambiguity introduced by differing linguistic and cultural norms. That is not to say that communication will be completely unambiguous, but the prevailing ambiguity will be resolved more easily by synchronous conversation between the drivers of the CPs engaging in active, spontaneous dialog.

We have not completely done away with asynchronous communication, but have instead moved into a different realm. Each member of a CP must have nearly equivalent knowledge of the artifacts owned by the CP. If the current driver modifies a code artifact owned by his CP, then the next driver must be familiar with that alteration. So within the CP there will be significant communication, almost all of which will be asynchronous in nature.

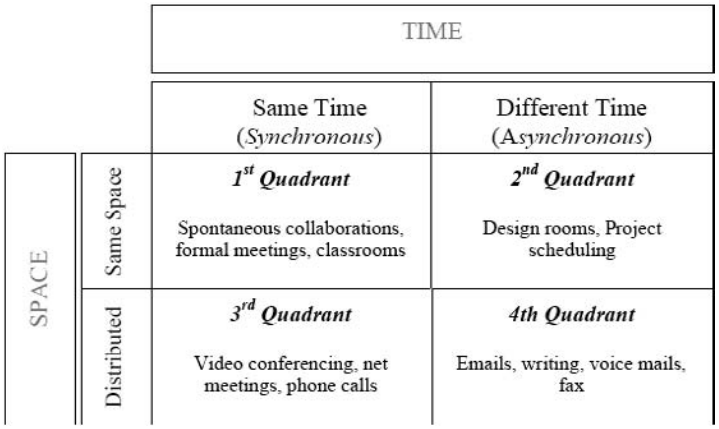
EVOLVING COLLABORATION TECHNOLOGIES

DeSanctis and Gallupe (1987) described a space and time classification framework in a 2x2 matrix (see Figure 3) that classifies tools based on the temporal characteristics of activities and location of the teams.

The 24-Hour Knowledge Factory paradigm fits into the 4th quadrant. More sophisticated tools than available asynchronous communication tools are needed to tap and effectively transfer tacit knowledge.

In distributed collaboration software development, tools that seamlessly enable communication without loss of tacit knowledge are critical. The communication methods that were successful in multi-site transfer of knowledge, particularly when dealing with remote or global teams, included teleconferencing, videoconferencing, chat, e-mail, and document exchange. While some of these methods are not necessarily effective for

Figure 3. Tool matrix



most of each shift in the 24-Hour Knowledge Factory system (those involving real-time communication), they might be particularly important during the handoff between each shift in order to convey a large amount of information in a short amount of time. Synchronous handoff is shown to be successful in the following tools.

Microsoft's NetMeeting (2006) facilitates the social interaction required for sharing tacit knowledge. IBM's Workplace Collaboration Services provides a full range of integrated communication and collaboration tools (IBM, 2005). Integrated development environments (IDEs) such as Eclipse are useful collaborative software development tools. Collaber is a collaboration framework that is built on Eclipse Software and includes features such as task management and group discussion. Eclipse goes a step further by its integration of JAZZ (Cheng, Hupfer, Ross, & Patterson, 2003), an awareness tool that allows developers to initiate and archive synchronous communication from the IDE in the code context. In all these distributed collaboration environments including the tools mentioned above, the developers rarely have a time overlap and hence synchronous communication tools are of no avail.

The tools required for a 24-Hour Knowledge factory using the CP model necessitate not only distributed remote collaboration, but are also limited to an asynchronous mode. Wiki (Cunningham, 2001) is a Web-based collaborative tool to use the strength of collective intelligence. MASE (Chau & Maurer, 2004) extends the wiki concept into the realm of agile software processes, and can be used for knowledge sharing by both co-located and distributed teams. The limitations with such tools are that users have to explicitly store documents and there is little to no context from which decisions can be analyzed by succeeding shifts. Furthermore, there is a strict dependency on the exact terminology in order to relate different content in the repository, which is a weak data mapping model.

Distributed document management is also critical in a collaborative development environment. There are many configuration management systems such as CVS (Berliner, 1990), IBM's ClearCase (Allen et al., 1995), and Subversion (Collins-Sussman, 2002). These do a good job in defining mechanisms for managing different versions of their work products. In such tools, the developers tend to get inundated with notification/updates of the various control events. Allowing the developers to configure their artifacts of interest is of good value as it reduces the information overload on the developer. Software tools such as CVS Watch (Berliner, 1990) allow the developers to define their artifacts of interest for which

they get automatically notified on any access or modification. WorkSmart.net (2007) is a hosted asynchronous collaboration service that provides the ability to configure a set of events whenever any action is taken. For example, an event may be triggered when a new folder is created, a document is deleted, or a new version of a document has been checked in.

Most of the commercial collaboration tools that have been built are either add-ons to existing tools or those that integrate several existing tools tuned to a synchronous mode. These tools rely significantly on user-initiated annotation and documentation, and do not address the project handoff from one user to another in an efficient manner. The free flow of information and assistance is vital to the 24-Hour Knowledge Factory environment. All of these needs have created an environment that requires innovative and more useful processes and tools.

CPro: Composite Personae Software Process

Software processes typically aim to improve quality and productivity. Quality and productivity are measured in terms of cost, effort, delivery schedules, and defects. However, many of these processes like PSP (Humphrey, 1995) assume single ownership of code. Extreme Programming (XP) (Nagappan & Williams, 2003) supports multiple ownership of code and assumes horizontal decomposition of work, with more than one developer sitting together working on the same task. This is no longer the case where CPs are collaborating in the 24-Hour Knowledge Factory. This work model poses many more challenges in terms of estimation, work allocation, knowledge transfer, and defect control. To overcome these problems and to facilitate offshoring in the 24-Hour Knowledge Factory model, we have come up with a software process that we call CPro.

Planning

When an overall schedule of the CP to complete a task needs to be obtained, one developer cannot estimate for the whole CP. This is because more than one developer present in the CP share the same task, and productivity can vary greatly from one programmer to the other. This has long been observed to be quite wide (Sackman, Erickson, & Grant, 1968; Humphrey, 1995). Due to a variety of factors, we can know a priori neither the subtask allocation within the CP nor the exact productivity of each member on any given task. Therefore, in CPro each developer gives his or her own estimates for all of the subtasks within a task. A *schedule caster* then executes a Monte Carlo simulation on the possibilities for productivity and project evolution. The result is a probabilistic schedule that project managers can use to estimate the delivery date of project artifacts within a specified degree of confidence.

Knowledge Transfer and Defect Control

Defect reduction is one of the primary goals of any software process that aims at improving quality and productivity. In the CP model, since tasks are vertically decomposed among drivers of the CP, each driver changes the state of the task. In the absence of a structured handoff procedure, defects may also occur due to lack of understanding of the current state of the task. Therefore, many of the current defect-reduction techniques cannot be utilized as is.

CPro makes use of the existing project artifacts as implicit handoff documents. This by itself not only conveys the work done in the previous shift, but also provides input to the current driver in the form of a project artifact. When the current driver reads the artifact to continue the work, he would be equipped with the knowledge of the job done by the driver in the previous shift. While reading the artifact, the developer in the current

shift would in effect review the artifact and could give suggestions and other feedback.

To achieve this, we suggest the use of Test-Driven Development (Williams, Maximilien, & Vouk, 2003). Test cases for some methods are written by one driver, which would act as a unit test document for that method. This also would serve as a handoff document. In this way, the current driver who codes on the method receives input from the previous driver in the form of unit test cases—the effect of this being that any discrepancies in understanding the design are clarified at this stage. Test cases must be machine interpretable and consequently lack the ambiguity of natural language. The developer in the second shift would then code the method defending the unit test cases, and the CP peer in the next shift would review the code. In this way, all three members of the CP would be aware of the code artifact in good detail, and extra communication in the form of status e-mail or documents are avoided.

MultiMind

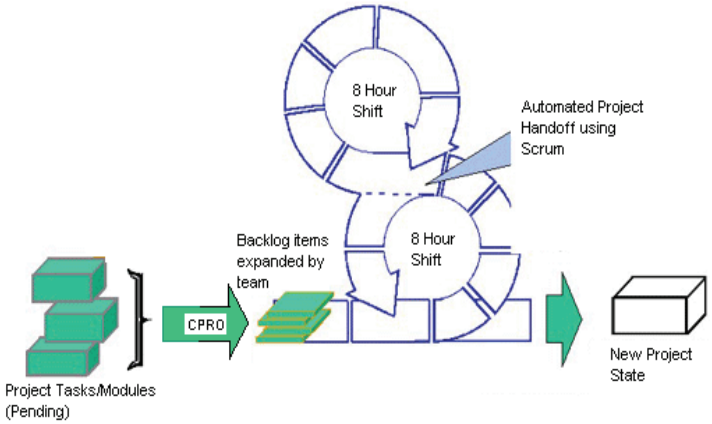
Suchan and Hayzak (2001) found that a semantically rich database was useful in creating a shared language and mental models. *MultiMind* is a novel collaboration tool under development and experimentation which aims to provide a semantically rich environment for developers collaborating using the CP method. MultiMind aims to improve upon DICE (Sriram, 2002) and other collaborative engineering tools.

Our initial implementation efforts have focused on providing a proof of concept for the 24-Hour Knowledge Factory model. Based on feedback from the initial users, we plan to judge the efficacy of the model and tune our development efforts accordingly. MultiMind is founded on the following technologies.

Software Processes

MultiMind is process-aware and guides the CP members along the CPro process. In addition to CPro, MultiMind also incorporates concepts from XP and Scrum. The tool automates some of the Scrum process, keeping developer intervention to a minimum. More specifically, the responsibility of creating work summaries has been offloaded from the developers to the embedded project management system. A templated scrum-style system is incorporated which, on sign-out, gathers quick statements about the anticipated future state of open tasks. On sign-in, during the subsequent shift, a scrum report is automatically generated

Figure 4. Handoff process in MultiMind



by synthesizing information from the previous scrum entry and the state of various archived project artifacts. Figure 4 depicts the usage of Scrum and CPro processes during handoff.

Lifestream

Objects and events relevant to the project are posted and logged into a monotonically increasing persistent database along with a time stamp. This database, sometimes called a Lifestream (Freeman & Gelernter 1996), allows human users and intelligent agents to create a local or comprehensive view of the state of the project at any given time. This capability is central to justify decisions made by one user to a different user that is trying to understand why a particular decision was made and the original acting user cannot be contacted in real time.

Towards facilitating the driver's understanding of the current state of the task, we have designed a study tool which draws inspiration from Activity theory. This is, of sorts, a decision support system in reverse: a decision justification system that justifies the decisions made by the previous workers. The integrated project knowledge base (Lifestream) is mined for relevant knowledge objects (project artifacts, speech acts, events) that were consumed by the previous worker during the course of his action. The aim is thus, to supply the driver with only relevant and condensed knowledge objects.

Speech Acts Theory

Speech Acts (Austin, 1963; Searle, 1975), used in linguistics, are acts of communication. The Speech Act theory systematically classifies communication messages into various acts, thereby establishing a common ontological base by which agents can communicate and understand each other. Both KQML (Knowledge Query Manipulation Language), developed by DARPA (Finin et al., 1993), and ACL (Agent Communication Language), developed by FIPA (O'Brien & Nicol, 1998), rely on the Speech Act theory for their protocol for communication between software agents in knowledge-based systems.

In the CP model, Speech Acts assist in synthesizing relevant information based on the high-level semantic nature of communication events. Existing asynchronous communication mechanisms that use free text lack significant semantic structure, making it impractical for a tool to classify the communication type or do meaningful analysis.

In the MultiMind tool, the communication entity is embedded as a conversation panel and it appears in the context of every project artifact. The conversation panel provides the facility to post messages based on a communication act, and these messages are logged to the Lifestream.

Vocal Annotations in Program Source Code

The best scenario for transferring code from one programmer to the next is to have the first programmer sit with the next programmer to go over the code line by line, and have him or her explain what the program does and why it was designed and implemented the way is was (Chiueh, Wu, & Lam 2000). This is not likely in the 24-Hour Knowledge Factory.

In the absence of appropriate documentation, maintenance of the code becomes a nightmare and grows worse over time (Miller, Johnson, Ning, Quilici, & Devanbu, 1992). Dekleva (1992) cites in these surveys that lack of documentation is one of the biggest problems people who maintain the code have to face. She takes the survey one step further and uses the Delphi technique to ask system maintainers what their largest obstacles are. The Delphi technique consists of three rounds of surveys where the consensus increases with each survey round. In all three rounds that were conducted, system documentation was in the top four issues seen by system maintainers, and it ended

up tied for third when the survey was over.

Raskin (2005) explains the need for the thorough use of internal code documentation, not only for improving code understandability but also improving reusability and productivity. Literate programming, introduced by Knuth (1984), is a methodology that combines the programming language with documentation language. The most well-known languages of literate programming are TeX, Cweb, and METAFONT (by Knuth himself). The most apparent drawback is that it necessitates a competent writing ability to be an effective literate programmer.

Fletcher (1997) describes how dictation becomes a more relaxed process since the user can now concentrate on the content of what is being dictated instead of the process of getting the text into the computer.

Combining code documentation and voice recognition may be a good way to use an established technology to solve a problem that is continuing to grow in the software industry. The prototype developed takes audio comments, translates them to text, and displays the text comments in the code. It also has the feature that the audio comments can be played back so if the translation is incorrect or not comprehended by the next programmer, he can playback the audio comment and hear exactly what was said.

Eclipse Extensions

While e-mail is a commonly used asynchronous communication method, the knowledge-sharing requirements of the 24-Hour Knowledge Factory make any one-to-one communication methods a poor choice for project communication. However, in order to convince software developers to move away from this method of communication, a convenient alternative that makes information available to the entire team must be provided. Project communication is not always technical in nature. Often, target dates, requirements decisions, priorities, and even team member schedules must be shared such that an entire team, regardless of where they are located, must be able to quickly assimilate. The solution under development proposes integrating tools into a common development environment. The Jazz project at IBM (Cheng et al., 2003) is a recent initiative that begins to address these concerns by providing a framework for distributed collaboration that is also process-aware and combines technical and managerial tasks into the development environment. This framework is built as an extension to the Eclipse Development Environment and provides many tools that are ideal for supporting the 24-Hour Knowledge Factory.

What Jazz does not provide is an alternative to e-mail that functions as a team-based project communication method. One solution may be discussion forums. Forums allow informal communication to be stored in a structured format that is accessible by all team members. Therefore, work is being done to study the existing functionality of the Jazz platform that would work well in the 24-Hour Knowledge Factory and to create appropriate plug-ins that integrate discussion forums into the Jazz platform.

CONCLUSION

As long-term strategic offshore partnerships evolve into the 24-Hour Knowledge Factory, new methods of work must be employed (Gupta, Seshasai, Mukherji, & Ganguly, 2007). Here, we have introduced the Composite Persona, a long-lived micro-team that has simultaneous individual and collective characteristics. CPs have the potential to resolve much of the difficulty in contemporary offshore development by mitigating the cultural, linguistic, and time zone differences between partners.

Modern groupware technologies cannot fully realize the possibilities made available by the 24-Hour Knowledge Factory and the CP method. Here, we have presented a new software process

(CPro) customized for use by developers organized into CPs. MultiMind, our new groupware tool and framework, builds upon a variety of novel technologies to aid software developers that employ CPro, and automates many management and process functions in order to reduce the need for explicit cooperation between the collaborating developers. Furthermore, we are experimenting with speech recognition technology as it can be applied to vocal annotation of project artifacts in distributed and international development. On the near horizon, we are also preparing extensions to the popular Eclipse integrated-development environment that will provide a smooth path for moving from contemporary offshore development methods into the 24-Hour Knowledge Factory.

Beyond technology, we have created an international partnership. With aid from the University of Technology–Sydney and the University of Wroclaw, we can test theory and tools and move closer to the 24-Hour Knowledge Factory.

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This work was previously published in the Information Resources Management Journal, Vol. 21, Issue 1, edited by M. Khosrow-Pour, pp. 89-104, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 8
Exploratory Study on Effective Control Structure in Global Business Process Sourcing[1]

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ABSTRACT

In an IT-intensive global business process sourcing (global BPS) project, the structure chosen to control knowledge transfer is critical. The objective of this study is to explore the effective control structure for knowledge transfer in IT-intensive global BPS project. The research methods used in this study are a case study and survey. First, a generic framework on the control structure for knowledge transfer is derived from extant literature. This framework is applied to a case analysis of a service provider in Mauritius. As a result of the case analysis, a model for control structure facilitating knowledge transfer in global BPS is derived. The model includes a social control mechanism, communication mechanism, project control mechanism as independent variables, and governance mechanism as a moderator variable. The degree of knowledge transfer and success of global BPS are used as dependent variables. The propositions describing the relationships between the variables are formulated. A total of 19 survey items were generated for these variables. As results of the survey, the model is revised and a set of more refined propositions are generated in the conclusion. Both service providers and clients can benefit from this study by focusing on control mechanisms that affect the knowledge transfer and BPS success.

INTRODUCTION

European and US corporations have been outsourcing non-core business processes as wells as supporting IT (Information Technology) to offshore vendors. This is referred to as offshore BPO (Business Process Outsourcing). The major reason for the offshore BPO is to reduce costs associated with the business process as well as access to quality services. In France, companies send their processes to French speaking offshore locations, such as Mauritius, Tunisia, and Romania. The processes usually outsourced is ranged from Sales/Marketing, Accounting/Finance, Human Resource, Information Technology, to Call Centers (UN, 2003).

Recently, setting up offshore subsidiaries rather than outsourcing from offshore vendors is increasing because of better communication and control. Therefore, the term global business process "sourcing" is more appropriate than "outsourcing." Global business process sourcing (BPS) includes market-based vendors as well as hierarchical subsidiaries or joint ventures (JV). The growth of global BPS is attributed to a combination of various factors, including advances in network technology and high-speed data networks.

In an IT-intensive global BPS project, knowledge transfer is critical for success (Kobitzsch et al., 2001). Defining user requirements and system architecture require communication and learning between users and the analyst and among team members (Ko et al., 2005; Sarker et al., 2005; Karlsen and Gttschalk, 2003; Curtis et al.,1988). Communication and learning involve information and knowledge transfer among the parties. The knowledge transfer in a Global BPS project cuts across between countries and involves the following type of knowledge (Kobitzsch et al., 2001): application knowledge, quality management knowledge, development (standards) knowledge and company culture knowledge.

While effective control mechanisms promote the acquisition, interpretation, and dissemination of the knowledge, ineffective control mechanisms distort and suppress knowledge transfer (Makhija and Ganesh, 1997). According to the type of knowledge, different control mechanisms could be appropriate (Turner and Makhija, 2006; Makhija and Ganesh, 1997; Fiol and Lyles 1985; Shrivastava, 1983; Tushman and Nadler 1978). As opposed to anecdotal reports emphasizing the importance of knowledge transfer and project management in global sourcing, this study explores effective control structures for knowledge transfer in Global BPS.

The overall approach of this study is qualitative, inductive and exploratory. Both service providers and clients can benefit from this study by focusing on control mechanisms that affect the knowledge transfer and BPS success. In this study, knowledge and information are used interchangeably due to their close relationships. Knowledge transfer in this study is defined as a systematically organized exchange of information and knowledge between entities (May et al, 2005).

RESEARCH METHODOLOGY

The research methods used in this study are a case study and survey. After reviewing the literature on control mechanisms, knowledge transfer and IS outsourcing, it was determined that no current theory is directly applicable to fulfill the objective. Therefore, 'ground theory building' methodology that builds theory in a grounded and inductive fashion is used for this study (Yin, 1984; Eisenhardt, 1989). First, a generic framework on the control structure for knowledge transfer is derived from extant literature. The framework consists of potentially important constructs to study the control mechanism for knowledge transfer. For the control mechanism, this study focused on hierarchy/subsidiaries structure, formal/informal control mechanisms and information systems. For

knowledge type, the study derived the following types of knowledge—sensitive knowledge, codifiable knowledge and no-codifiable knowledge.

This framework is applied to a case analysis of a service provider in Mauritius to explore effectives control mechanism for transfer of each type of knowledge in Global BPS. As results of the case study, a model for "control structure facilitating knowledge transfer in Global BPS" is derived. The model includes a social control mechanism, communication mechanism, project control mechanism as independent variables, and a governance mechanism as a moderator variable. The degree of knowledge transfer and success of Global BPS are used as dependent variables. The propositions describing (1) the relationships between the identified control mechanisms and the level of the knowledge transfer, and (2) the relationship between knowledge transfer and the success of Global BPS are derived.

To refine the model, the survey method is used. A total of 19 questionnaire items were generated for the constructs in the research model. A sample of the service providers in the Global BPS industry in Mauritius was asked to rate each item on a five-point scale anchored on strongly disagree (1) and strongly agree (5). Convenience sampling was adopted, i.e. companies were selected on the basis of easy access. The findings can not be extrapolated to all GBPS business but merely provide an indication of the correlation in the sample frame. There is a need for more detailed interviews and survey research in the future. Bias could exist in this study because it is based a small sample – a major limitation of this research. The model is revised based on indications from the collected data. Finally, a set of more refined propositions are generated in the conclusion.

The research method was designed, not without constraints, to explore control structures used in GPBS. The constraints are associated with the fact that the research data can be only obtained from outside of Korea. It is the location of the prime investigator of this study and the only Korean speaking country in the world. For this reason, it is hard to find Global BPS data in Korea either from service provider perspective or a client perspective. This is major obstacle in the progress of this study.

KNOWLEDGE TRANSFER AND CONTROL STRUCTURE

Hierarchical vs. Market Control

Control mechanisms in IOR (Inter-Organizational Relationships) are associated with transaction costs for monitoring opportunistic behavior of the partner (Williamson, 1979; Williamson, 1991). As the concern for the opportunistic behavior of the partner is high that is transaction costs are high, then the hierarchical control mechanism (i.e. insourcing) is appropriate. When the firm can protect its contract from the opportunistic behavior of the partner by specifying all the contingencies on the contract, the market mechanism (i.e. outsourcing) is appropriate (Hart, 1989). In the middle of the continuum, the hybrid control mechanism can be used (Gulati and Singh, 1998; Decker, 2003).

Opportunistic behavior of the vendor is also a concern in inter-organizational knowledge transfer. According to Kobitzsch (2001), sensitive technologies such as encryption are difficult to transfer to independent partners. The newest technologies are transferred overseas through subsidiaries rather than licensing (Mansfield and Romeo, 1980). As technological intensity increases, organizations adopt hierarchically organized work mode to effectively utilize the exclusive patent of the new technology (Jones, 1987). Hierarchical mechanisms involve explicit rules and procedures to tightly monitor the task completion (Ouchi, 1979). In similar way, the control structure of BPS could be influenced by sensitivity of knowledge transferred in BPS. For outsourcing the commodity type of process where

the sensitivity of the knowledge transferred is low, market mechanisms would be appropriate. Hierarchy mechanisms such as subsidiaries would be more appropriate when the knowledge transferred is sensitive, and thus the possibility of vendor's opportunistic behavior is a concern.

Formal vs. Social Control

Compared to TCE, organizational scholars are of the view that the control structures in IOR are influenced by knowledge characteristics associated with the task (Eisenhardt, 1985). The more predictable the knowledge to be transferred in IOR is, the formal and structural controls (such as standard operating procedures/rules and clearly established routines) are likely to be (Makhija and Ganesh, 1997). The rules include both the rules concerning processes and rules specifying standards of output or quality. In the global BPS arrangement, when knowledge transferred can be defined in advance, the formal and structural controls can be used.

On the other end, when the knowledge transferred in IOR is implicit and can not be specified in advance, informal and social control is better due to its flexibility (Makhija and Ganesh, 1997). Trust is the principal mode of social control (Adler, 2001). Trust is considered to foster knowledge transfer and learning because trust increases interactions between individuals and helps to learn tacit knowledge (Kale et al., 2000). According to Davenport and Prusak (2000), trust reduces the fear of opportunistic behavior of the other in terms of taking advantage of the knowledge gain. Thus, mutual trust in the relationship is a prerequisite for the acquisition of the embedded implicit knowledge of the individuals. According to Hewett and Bearden (2001), mutual trust is a basis of the commitment defined as the pledge of relationship continuity between partners. Commitment on prescribed agreements could also facilitate communication and knowledge transfer to achieve mutual goals (Das and Teng, 1998; Liefer and Mills, 1996).

Socialization is another form of social control, which facilitates transfer of sticky knowledge embedded in individuals, contexts or locations (Szulanski, 2000). Other types of social control include meetings, visits to parent company facilities in JV and parent company interaction, training engineers of parent company by engineers of JV, and transfer and rotation of personnel (Inkpen and Dinur, 1998). Heeks et al. (2001) assert that knowledge transferred in global software outsourcing is tacit and informal. To facilitate the knowledge transfer between outsourcer and the service provider in BPS, social control may be important.

Information Technologies

Social control can not be used as much as possible due to the geographical distance I Global BPS. In this case, socialization can be complemented with technologies that mitigate temporal and spatial barriers and allow flexible and frequent communication and coordination between partners (Applegate and Gogan, 1995). Depending on the task, the extent of coordination between partners can vary substantially. At one extreme, the partners may have minimal coordination requirements to achieve their goals. At the other extreme, knowledge transfer can be extensive, and thus continuing mutual adjustments between partners are required. For a simple coordination, a simple messaging system can be used. For a richer communication, videoconference technology can be used. Videoconference technology allows virtual teams to access and share the knowledge of remotely located members (Davenport and Prusak 2000). Control structure for each type of knowledge discussed above is summarized below (Table 1).

CASE STUDY DESCRIPTION

Data sources for the INFO case include interviews with general manager and programming team

Table 1. Knowledge type and control structure [Adapted from Kim (2007)]

Knowledge Type	Control Structure
Sensitive Knowledge	Hierarchy
Codifiable Knowledge	Formal and Structural Control
Less Codifiable Knowledge	Social Control /Information Technology based Control

leader, and relevant publications regarding the firms. General managers and team leaders of the programming team were interviewed for a two-day period to obtain the case data. Each interview took about one hour and was conducted face-to-face. At the onset of each interview, the goal of this study was briefly explained. The interviewee was then asked unstructured and semi-structured questions. During the unstructured interview, the interviewee was asked to tell their sourcing story. Then, semi-structured questions regarding the goal of knowledge transfer, transferred knowledge, the mode of knowledge transfer and the effectiveness of the knowledge transfer. Relevant publications, such as company and industry publications, were utilized as well.

Established in 1994, INFO (France) is a software development company for developing front- and back-end software for hypermarket (INFO, 2006). INFO (France) is a subsidiary of the French Retailing Group. INFO (France) has more than 450 customers, mainly supermarkets and hypermarkets in France and the south of Europe. INFO has provided the highest quality service through the collaboration with 150 companies (INFO, 2006). Since 1997, numbers of French competitors, like Auchan and Carrefour, focused on reducing costs through outsourcing, which creates fierce competition. Since the retail industry is intensively competitive with slow growth and low margins, as a part of LCL, INFO knew that effective cost control is vital to achieve low pricing. In June, 2005, INFO (Mauritius) was set up for software development and test as well as IT help desk for INFO (France). The French Retailing Group intends to cut costs, and thus to strengthen their competitiveness in European market.

While INFO (Mauritius) is denoted as INFO (M), INFO (France) is denoted as INFO (F). INFO (M) has a staff of 16. The organizational structure of INFO (M) consists of a general manager and team leaders leading a group of programmers.

The following shows how their work is done:

1. The project manager (PM) in France sends project specifications.
2. The team leader studies the project description and estimates the number of developers and the time. Project management tools developed by INFO (F) are used for planning.
3. The team of programmers develops and tests the program.

In INFO (M), all work done in INFO is automatically saved in France. This is how they monitor the process using Inter-Organizational Systems.

According to the general manager, quality is the most important in BPO. According to the team leader, quality implies the followings: (1) once the team leader submits the program to PM in France, the PM should not send the program back to Mauritius for correction; and (2) keep the code of ethics that are 'instructions' about writing sufficient codes.

Communication, Training and Socialization of Team Leader

According to the team leader, sufficient quality products are ensured by sufficient communication with the project leader in France. Their communications start as the PM in France sends project specification. During this process, teams in Mauritius and the project leader in France share

knowledge. 80% of their communications is done via IP phone. The team leader communicates with the project leader 5-10 times per day using IP phone. The rest of the communications are done via mail or video conference. During this process, two-way communication occurs. According to the team leader, "Sometimes, developers in Mauritius suggest better ways of doing things. So this is two-way communication." According to the team leader, due to IP phone, videoconference and teleconference, she senses no communication barrier. The only barrier she senses is 2-3 hours of time difference.

The team of programmers had a lot of training regarding "Dos and Don'ts", ethics of the codes, and ways of programming. The training program deals with how we think so that we communicate better with the PM in France. As results, we produce better products. Once per week the team gets trained via videoconference. Frequent trainings are done via telephone or teleconference. In January 2006, the team leader went to France to have technical courses on a visual studio .net. She learned the rules and procedures about how to use .net. IT engineers from France are staying in Mauritius for two years. To make the knowledge transfer easier, the programmers had two-day intercultural training. The cultural training helped the programmers know what INFO (F) is expecting from us. According to the team leader, "personally, I do not feel cultural difficulties." During her visit to France, the team leader had a chance to associate with the French team through social gathering. She said, "trust is important to ensure a sufficient team work."

Communication, Training and Socialization of General Manager

According to the general manager, programmers in INFO (M) had to test the 'limits', which means they had to do the maximum test. According to the manager, "the programmer has capability (competency) but they need to be aware of quality." The team of programmers that produces higher quality programs gets better projects (more challenging projects and risky projects). According to the general manager, "Mauritius people like to learn." Therefore, monetary compensation is less important. The team leader that I interviewed said the same thing. When I asked, "what is reward for writing sufficient codes?" she replied, "reward for sufficient quality is personal satisfaction and getting assigned to a sufficient project. Sufficient projects means challenging and risky projects", according to her.

In summary, General Manager's main focus is HR:

- ✓ Motivating programmers
- ✓ Following up project quality, evaluating personnel, and compensating.

The general manager went to France twice (each visit lasts one week). In turn, the France manager came to Mauritius once. They communicate everyday by e-mail, video-conference, and telephone. The knowledge transferred between managers is "do's and don'ts". This is always reciprocal knowledge transfer. For example, while the manager in Mauritius communicates regarding labor law in Mauritius, the French manager transfers the code of ethics. At the beginning, the meetings were not structured. The meetings were Q&A-type. The meetings with the manager in France were held bi-weekly. Another bi-weekly meeting was held for project follow-up. According to the general manager in Mauritius, she can have a meeting when needed.

The manager in Mauritius did not feel that this process was difficult. According to her, inter-cultural training for two days helped this process go easy. Social gatherings in France and Mauritius after work and during weekend helped the transfer of tacit knowledge such as cultural knowledge. Visits and frequent communications helped to build strong credibility.

FINDINGS FROM CASE

The key features of knowledge type and control structures are examined in Table 2.

Finding 1: Governance and Social Control Mechanisms

- Setting up subsidiaries might reduce concerns for provider's opportunistic behavior in relation to sensitive knowledge.
- Social gatherings facilitate transfer of embedded knowledge such as cultural knowledge.

This case indicates that setting up subsidiaries could have more control over the operations and better communication. To ensure code writing is sufficient without bugs, programmers in Mauritius and the project leader in France needed sufficient communication. Setting up subsidiaries facilitated this communication process.

The Mauritius and France teams met through training events and regular job rotations. Social gatherings helped the transfer of tacit knowledge, such as cultural knowledge.

Finding 2: IT-Based Communication Mechanism

- Due to geographical distances between the provider and the client, IT-based communication mechanism plays a critical role in the transfer of less codifiable knowledge.

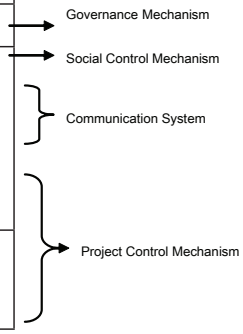
As the PM in France sends the project specification, the communication among project team starts. Sufficient communication regarding the system requirements ensures the quality of the program. Non-codifiable knowledge regarding requirements was exchanged using various two-way communication mechanisms, such as IP phone, e-mail, and video conference.

Finding 3: Project Control Mechanism

- Technical training, inter-cultural training, liaison engineer facilitates transfer of less codifiable process knowledge.
- Formal and structural control mechanisms, such as operating rules and program guidelines were used to transfer the codifiable process knowledge.

Table 2.Control Structure Used in INFO (M)

Knowledge Type	Control Structure
Sensitive Knowledge	• Subsidiaries
Less codifiable Process Knowledge	• Socialization • Two-way communication via video conferencing, teleconferencing, IP phone, e-mail. • Technical Training • Cultural Training • Liaison Engineer deployment
Codifiable Process Knowledge	• Programming guideline such as code of ethics and quality standard • Manual for Project Management Tool



Technical training regarding "Dos and Don'ts", code of ethics, and methods of programming helped the programmers understand the technical expectation of INFO, France. The technical training as well as inter-cultural training helped communication and knowledge transfer through understanding of mutual expectation. As a result of better communication, better products were produced. A liaison engineer from France also facilitated knowledge transfer between INFO, France and Mauritius.

Process knowledge was codified as much as possible via programming guidelines, such as code of ethics and manual for using project management tool. This relates to the standardization issue of the project management. Standardization of methods, diagrams and tools facilitate communication among project members (Valacich et al., 2001). INFO case also indicates that the general manager made sure that proper project team is composed for the project. Composing project team with the employees who have the capability to absorb new knowledge is another way to facilitate the knowledge transfer. This is referred as "effective human resource allocation" or "organizing effective project team." In summary, this case indicates that relationships between the project control mechanism and knowledge transfer is worthy of an investigation. The project control mechanism in relation to knowledge transfer is to be discussed in the subsequent section.

Finding 4: Outsourcing Success

- Socialization, frequent communication and project control mechanism facilitate knowledge transfer, which in turn leads to high quality outcome.

This case indicates that socialization, frequent communication and a project control mechanism facilitate knowledge transfer and eventually lead to the success of BPS:

- Socialization -> Transfer of cultural knowledge-> Better Communication -> Sufficient outcome
- Socialization -> Trust building -> Promotion of knowledge transfer-> Sufficient outcome
- Communication -> Knowledge transfer -> Sufficient outcome
- Training -> Knowledge transfer -> Sufficient outcome

Finding 5: Research Model for Control Mechanism that Facilitates Knowledge Transfer in Global BPS

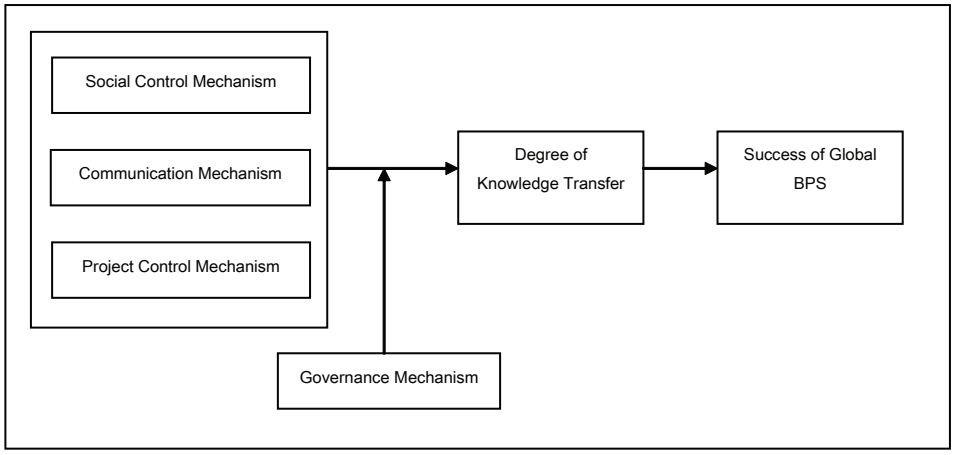
The following research model is derived as results of the case findings:

While governance mechanism is used for contractual structuring for the institution to align the partner's incentives, social, communication, project control mechanisms are used for the procedural structuring to align their joint processes (Sobrero and Schrader, 1998). While a governance mechanism is set as the inter-organizational relationship is initiated, social mechanisms are instituted afterwards. Due to these differences, the governance mechanism in this study is used as a moderator variable rather than an independent variable. In this study, the governance mechanism as a moderator variable is assumed to reduce or enhance the influence of the independent variables on knowledge transfer. The following propositions were derived.

Propostion1: *The use of social control is positively associated with the level of knowledge transfer in Global BPS.*

Propostion2: *Properly designed and reliable communication mechanism is positively associated with the level of knowledge transfer in Global BPS.*

Figure 1. Research model of effective control structure in global BPS



Propostion3: *The use of project control mechanism is positively associated with the level of knowledge transfer in Global BPS.*

Propostion4: *Control mechanism with higher level of hierarchy governance contributes to higher level of knowledge transfer.*

Propostion5: *The level of knowledge transfer is positively associated with the success of Global BPS.*

SURVEY DESIGN AND DATA COLLECTION

In the prior portions of the paper, (1) literatures on control mechanisms and knowledge transfer were described and integrated, (2) an exploratory case study was performed, and (3) research model for control mechanisms in Global BPS was derived. In the next portion of the paper, we confirm and refine the research model using survey method. This section discusses how the questionnaire items were derived to measure each construct in the model.

The questionnaire items were either adapted from the previous studies or developed in this study. Before distribution of the survey, the contents validity of the survey was rechecked by two academic colleagues who are experts in organizational strategy and project management. In summary, this checking process is a two-stage process. The first stage was involved with deriving the survey instruments based on previous research. The second stage involves rechecking the instrument by domain experts. This two-stage process ensured that the instrument covers the range of meanings included in the construct (Pitt et al., 1995). The items of Table 3-6 were included as part of a larger survey. Each item was anchored by five-point scale ranging from 1 = strongly disagree to 5 = strongly agree.

Social Control Mechanism

Trust and commitment of the social control mechanism were asked to measure the level of the social control mechanism. Trust and commitment were measured by modifying the instrument in Lee and Kim (1999) and Lee and Cavusgil (2006) (Table 3).

Table 3. Measure of social control

Question Posed (TR: Trust, CT: Commitment) **In our relationships...**
TR1. We make beneficial decisions under any circumstance.
TR2. We are willing to provide assistance to our counterpart without exception
TR3. We are sincere at all time.
CT1. We perform prespecified agreements.
CT2. We faithfully provide prespecified support in a contract.
CT3. We always try to keep each other's promises.

Table 4. Measure of IT-based communication mechanism

Question Posed (CM: Communication)
CM1. We and our counterparts have properly designed an interorgazniational communication interface.
CM2. There is no error when we communicate with our counterparts using the IT-based communication infra.

IT-Based Communication Mechanism

Having properly designed and reliable communication mechanism were asked to measure the level of IT-based communication mechanism. A properly designed communication mechanism is associated with providing a variety of media, such as phone, video-conferencing, and e-mail. Reliability of the system represents the user's sense of assurance or certainty about the communication mechanism (DeLone and McLean, 1992).

Project Control Mechanism

The control in IS project management is associated with defining the followings (Valacich et al., 2006; Murray and Crandall, 2006; Beise, 2004; Dvir et al., 2003):

1. project goals and requirements,
2. activities to be performed for each phase of system development,
3. deliverables to be produced for each phase,
4. resources and time requirements for each phase,
5. tools and standards used for each phase,
6. responsibilities of the project members.

Sharing the project goal among members, having a clear project plan, allocating adequate resources are critical to making knowledge flow smoothly among project members (Karlsen and Gottschalk, 2004). Based on common and shared goals and plans, the teams generate a high degree of focus and goal accomplishment (Goffee and Jones, 1996). In addition, composing project team with the employees who have capability to absorb knowledge is another way to facilitate the knowledge transfer. Efficient management of organizational knowledge deals with having individual members interact and collaborate (Goffee and Jones, 1996; Grant, 1996; Nonaka and Konno, 1998). Participative culture is essential to share knowledge among individual project members.

The standardized project management method as well as project documentation, such as Project Workbook and Gantt Chart, allow project mem-

Table 5. Measure of project management

Question Posed (PP: Project Planning, OSC: Organizational Structure and Culture, SD: Standardization)
PP1. We have realistic project goals.
PP2. We have adequate overall project plan.
PP3. We adequately allocate our project resource.
OSC1. We have effective project team.
OSC2. We and our counterpart have an understanding about knowledge sharing needs.
OSC3. We have an adequate culture for knowledge transfer.
SD1. We have adequate standardized documentation for project management. (e.g. Project Workbook, Gantt Chart)
SD2. We share project management method with our counterpart.

Table 6. Measure of knowledge transfer and success of global BPS

Question Posed (KT:Knowledge Transfer, SG: Success of Global BPS)
KT. During this project, my interactions with counterpart have increased my ability to ask penetrating questions about this project.
SG. Through this project, our client can approach excellent world-wide technical human infra.

bers to communicate effectively (Valacich et al., 2001). The following categories of questionnaire items—(1) project planning, (2) organizational structure and culture, and (3) standardization—were used to measure the level of project control mechanism.

Governance Mechanism

In this study, a governance mechanism is used as a moderator variable to moderate the influence of the independent variables on knowledge transfer. A sample of service providers were asked to indicate their governance structure among three categories of the governance mechanism is used in this study: vendor, subsidiaries and jv mechanisms.

Knowledge Transfer and Success of Global BPS

The questionnaire item to measure the degree of knowledge transfer was adopted from Ko et Al. (2005). The original items to measure the degree of knowledge transfer between clients and consultants in the outsourced IS project were modified to be relevant in Global BPS.

Outsourcing success can be measured from either a client or vendor perspective. While Lee and Kim (1999) measurements were from the client perspective, Karlsen and Gottschalk (2004) measurement were from the vendor perspective. These measurements were modified to be relevant in the context of Global BPS. In this study, the success of Global BPS is measured by the degree of realization of the client's benefits perceived by the service provider; that is, the approach to excellent world-wide technical human infra.

The survey was distributed to 17 service providers in Mauritius. Mauritius is a French and English speaking country where the majority of the population is of Indian descendant. Viewing their dual language speaking manpower as competitive advantages, the government aspires to capture a share of English and French speaking BPS market. The government has been "investing

massively to assemble the pre-requisites in terms of modern infrastructure, appropriate policy, legal framework and fiscal incentives" (Board of Investment, 2003). Recently, the government set up Cyber City in Ebene, which is 15 Km from the capital city, Port Louis, to attract BPS industry.

The respondents of the survey must be able to describe a control structure and degree of knowledge transfer. Those individuals who were considered to be ideal for this study are directors and managers. The profiles of the respondents are summarized in Table 7 in the following section. Convenience sampling was adopted. That is, sample companies were selected on the basis of easy access due to acquaintance. First, the sample companies were contacted via telephone. If company agreed with the survey, then the survey was distributed via e-mail. To ensure return of the survey, the sample companies were then contacted for a second time via telephone.

SURVEY ANALYSIS

Of 17 surveys, 15 were used for analysis. The remaining questionnaires were removed because they were considered as outliers. Table 7 shows descriptive statistics of the surveyed firms. 53% of the sample companies were 2-4 years old. 73% of them are less than or equal to 4 years old. 100% of the sample businesses are in the BPO industry. 53% of the sample companies are considered themselves to be in ICT (Information and Communication Technology) sector of BPO. The respondent's description of ICT sector included batch Information processing, data capture, e-business and ERP (Enterprise Resource Planning). 95% of the respondents are either a director or manager. 40% of respondents are a general manager and 26% of them are an IT manager.

For governance structure question, 75% of the sample answered that the governance structure of its firm is either subsidiaries or JV. Most of these

Table 7. Descriptive statistics for sample companies

		Frequency	Percentage
Company Age	Less than 2 years	3	20%
	2~4 years	8	53%
	4~6 years	2	13%
	Over 6 years	2	13%
Industry (BPO)	ICT	8	53%
	Call Center	2	13%
	Accounting	2	13%
	Finance	1	6%
	Not Answered	2	13%
Position	Manager	9	60%
	Director	5	33%
	Engineer	1	6%
Department	Management	6	40%
	IT	4	26%
	Finance	1	6%
	Software Development	1	6%
	Etc	3	20%

subsidiaries and JVs also have separate businesses from the mother company as the vendor. Therefore, most of them have the governance structure of subsidiaries/vendor or JV/vendor.

Due to a small sample size, Kolmogorov-Smirnov Goodness-of-Fit Test for each variable was performed to test the sample distribution against a normal distribution. Except TR2, TR3, CT3 and OSC1, none of variables had normal distribution ($p < .05$). Due to the fact that most of the variables do not have a normal distribution and the sample size is less than 30, interpretation of the results is limited and done cautiously.

The sample companies seem to agree that they have trust and commitment in the Global BPS relationships. This is based on the consensus measures and means of the social control variables in Table 8. All social control variables except TR1 have consensus measure (i.e. Cns) greater than or equal to 0.67 and mean over 4.0. The consensus measure ranges from 1 to 0 (Tastle and Wierman, 2006, Tastle et al., 2005). While the complete agreement is defined as 1, complete disagreement is defined as 0. Consensus denoted as Cns and dissention denoted as Dnt are related and given one, the other is easily calculated by Cns= 1- Dnt. The first five columns of Table 8 show how many of the sample companies chose each response in the survey. The sixth column provides the mean of each variable with SA=5, A=4, N=3, D=2 and SD=1. While Cns and Cns% are the consensus values in decimal and rounded percent, Dnt and Dnt% are the dissention values in decimal and rounded percent.

The surveyed firms less agree that they have proper IT-based communication interface (Cns 0.53, mean 3.67). But they seem to more agree that communication is fairly reliable (Cns 0.68, mean 3.93). This is attributed to their choice of communication media. The firms were asked to

Table 8. Consensus and dissent measures

Variables	SA	A	N	D	SD	Mean	Cns	Cns%	Dnt	Dnt%
TR1	4	4	6	1	0	3.73	0.66	66%	0.34	34%
TR2	10	1	4	0	0	4.40	0.67	67%	0.33	33%
TR3	12	3	5	0	0	4.60	0.82	82%	0.18	18%
CT1	7	3	5	0	0	4.13	0.67	67%	0.33	33%
CT2	8	4	3	0	0	4.33	0.71	71%	0.29	29%
CT3	12	2	1	0	0	4.73	0.83	83%	0.17	17%
CM1	5	4	2	4	0	3.67	0.53	53%	0.47	47%
CM2	5	5	4	1	0	3.93	0.68	68%	0.32	32%
PP1	7	6	2	0	0	4.33	0.75	75%	0.25	25%
PP2	5	5	4	1	0	3.93	0.68	68%	0.32	32%
PP3	4	8	3	0	0	4.07	0.80	80%	0.20	20%
OCS1	3	9	2	1	0	3.93	0.78	78%	0.22	22%
OSC2	5	5	5	0	0	4.00	0.72	72%	0.28	28%
OSC3	5	6	1	3	0	3.87	0.62	62%	0.38	38%
SD1	2	7	3	2	1	3.47	0.59	59%	0.41	41%
SD2	3	8	2	2	0	3.80	0.70	70%	0.30	30%

SA – Strongly Agree / A – Agree / N – Normal / D – Disagree / SD – Strongly Disagree / Cns – Consensus / Cns% – Consensus as a percentage / Dnt – Dissent / Dnt% – Dissent as a percentage

rate the frequency of the media choice using a five-point scale anchored on very infrequently (1) and very frequently (5). The most frequently used media are E-mail (4.87) and Telephone (4.33) while the least frequently used media is Video Conferencing (2.20). E-mail plays a key role to motivate knowledge sharing between knowledge workers by mitigating temporal and special barriers (Hendricks 1999). However, e-mail has limitation to deliver cues of the communicator thus less effective to transfer knowledge than video conferencing (Sapsed, et al., 2005). This is also the case with telephone communication. In contrast, videoconference technology is effective to access and share the knowledge of remotely located virtual team (Davenport and Prusak 2000; DeSanctis and Moge, 1999).

The companies agree that they have realistic project goal (PP1), overall project plan (PP2), adequate project resource (PP3), effective project team (OSC1), appropriate knowledge sharing culture (OSC2, OSC3) and project management method (SD1). Compared to other aspects of the project management control, they less agree that they use standardized project document (SD1) with Cns 0.59 and mean 3. 47.

The correlations between variables were checked and the results are presented in Table 9.

The following is notable: while project control variables have a correlation with only Success of Global BPS, social control variables and communication variables have a correlation with both Knowledge Transfer and Success of Global BPS. This indicates that the Project Control Mechanism is a determinant of Success of Global BPS rather than Knowledge Transfer. Not all the variables in Social Control Mechanism have a correlation with knowledge transfer. The construct validity and content validity of the social control mechanism were already proven because the instrument was validated in the previous research.

In the future, with more sample data, the construct validity of the Communication Mechanism and Project Control Mechanism needs to be performed. Success of Global BPS and Knowledge Transfer show a correlation. The governance mechanism does not have a correlation with Knowledge Transfer or Success of Global BPS. Most of the samples had a hierarchical governance structure of either subsidiaries or JV; that is, there was not much variation in governance mechanism. In the future, with larger samples, the effect of governance mechanism as moderator variable should be tested.

The findings can not be extrapolated to all service providers but merely provide an indication of the correlation in the sample frame. A margin of error also exists in this study because this study is based on a small sample. This is the major limitation of this research. More rigorous survey including a more diverse sample from

Table 9. The results of correlation analysis

		Knowledge Transfer	Success of Global BPS
Success of Global BPS		0.005**	
Social Control Mechanism	TR1	0.303	0.454
	TR2	0.282	0.043*
	TR3	0.273	0.463
	CT1	0.246	0.371
	CT2	0.028*	0.078
	CT3	0.050*	0.277
Communication Mechanism	CM1	0.126	0.014*
	CM2	0.034*	0.018*
Project Control Mechanism	PP1	0.460	0.107
	PP2	0.405	0.107
	PP3	0.260	0.350
	OSC1	0.493	0.030*
	OSC2	0.092	0.015*
	OSC3	0.413	0.041*
	SD1	0.246	0.020*
	SD2	0.257	0.038*
Governance Mechanism		0.258	0.182

*** significant parameter at p=0.01*

**significant parameter at p=0.05*

major offshoring countries like India, China, Philippines or Ireland remains as future research. Nonetheless, the findings still provide some fairly significant insights in *exploratory research*.

As a result of this study, the initial research model could be revised, as shown in Figure 2. The difference with the initial model is that the revised model incorporates the analysis results—project control variables have a correlation with Success of Global BPS rather than Knowledge Transfer. The creation of this model was driven by a process understanding of knowledge transfer and their impacts, Global BPS success. The process model has three components: the control of knowledge flow, the degree of knowledge transfer, and the consequences of the knowledge transfer (i.e. Success of Global BPS). Each of these steps is a necessary, but not sufficient, condition for the resultant outcome.

The following propositions are derived as results of this study:

1. Commitment as social control mechanism is positively associated with the level of knowledge transfer in Global BPS.
2. A properly designed and reliable communication mechanism is positively associated with the level of knowledge transfer.
3. Structural, cultural and standardization aspects of a project control mechanism are positively associated with the level of success in Global BPS.
4. The level of knowledge transfer is positively associated with the level of success in Global BPS.
5. A control mechanism with more hierarchical governance contributes to a higher level of knowledge transfer.

DISCUSSION AND CONCLUSION

Despite the limitation of this research stated in the previous section, this study made a contribution. This study found the research model and propositions that would help both academics and practitioners to understand the effective control structure in Global BPS. It was widespread notion that Global BPS is governed by a market mechanism. Unlike early offshore BPO, this study showed that business process is increasingly sourced under hierarchy governance in a form of overseas subsidiaries or JV. Under this trend, this study also showed that the success of Global BPS is influenced by (1) a commitment and proper communication systems facilitating knowledge transfer and (2) a project control mechanism.

These results have some implications for countries like Korea. The recent decrease in IT exports, especially in the area of hardware, such as wireless communication equipments prompts Korea to rethink about the structure of IT exports—more balanced mix of exports in hardware and IT services (ICA 2004). The IT service industry in Korea has the best infrastructure in the world in terms of technology as well as human resources. However, language is a major barrier for providing IT services to other countries. The language barrier makes knowledge transfer difficult. The results of this study can be noted to build control structure facilitating knowledge transfer.

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ENDNOTE

[1] This study is conducted with the support of Korea Research Foundation

This work was previously published in the Information Resources Management Journal, Vol. 21, Issue 3, edited by M. Khosrow-Pour, pp. 101-118, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 9
An Outsourcing Acceptance Model:
An Application of TAM to Application Development Outsourcing Decisions

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ABSTRACT

The use of outsourcing is expanding rapidly. This study empirically tests a model of application development outsourcing acceptance based on the technology acceptance model (TAM). TAM suggested perceived usefulness and ease of use mediate the effects of other variables on users' attitudes towards a technology. The model tested in this study suggests perceived usefulness and ease of use of outsourcing mediate the effects of the external environment, prior outsourcing relationships, and risks on decision-makers' attitude toward application development outsourcing. One hundred and sixty respondents to a survey sent to 3000 IT decision makers provided data to confirm the applicability of TAM and the influences of these external variables. Support for applying TAM in this alternative context was found. Three sub-dimensions of risk, project management, relationship, and employee risk emerged. Project management and employee risks along with prior relationships were found to significantly influence decision maker perceptions about application development outsourcing.

INTRODUCTION

An increased reliance on information technology (IT) for success combined with the rapid, accelerating rate of IT change, has intensified both the importance and complexity of managing this now vital corporate resource. IT outsourcing, the transferring of all or part of a company's IT

functions to an outside party, offers additional alternatives to organizational decision makers. Hence, there is an increasing focus on determining the correct sourcing strategy for IT and IT services (King, 2001). However, choosing the appropriate IT functions to outsource and the best outsourcing vendor is very complex (Kern, Willcocks, & van Heck, 2002). This is especially true now because the motivation for IT outsourcing has moved beyond traditional cost cutting or efficiency gains to become more transformational. IT outsourcing now plays a much more strategic role, enabling companies to be more adaptive and respond quickly to new opportunities (Mazzawi, 2002).

Kodak brought IT outsourcing to the forefront with their landmark decision to outsource their IT functions in 1989. Recent surveys indicate that around the globe, firms of all sizes across many industries view outsourcing as a realistic alternative for some or all of their IT functions (Barthelemy & Geyer, 2001; Kakabadse & Kakabadse, 2002). The use of IT outsourcing continues to grow at a phenomenal rate (Kernet al., 2002; Ross & Westerman, 2004).

A wide variety of IT functions are outsourced. This study focuses on one particular function, applications development (AD), defined as any efforts in the organization involved with the analysis, design, or implementation of information systems. AD was identified in multiple prior studies as an IT function commonly outsourced (McFarlan & Nolan, 1995; Hurley & Schaumann, 1997; Elmuti & Kathawala, 2000; Ross & Westerman, 2004). Furthermore, recent surveys indicate that AD outsourcing is on the rise (Hurley & Schaumann, 1997; Ketler & Willems, 1999; King & Cole-Gomolski, 1999). More and more AD outsourcing is also done offshore which adds complexity to the decision making process (Elmuti & Kathawala, 2000; Robb, 2000; Prencipe, 2001). Thus, a better understanding of the AD outsourcing decision is important. More importantly, this knowledge may help to improve the understanding of other outsourcing decisions.

A prior outsourcing study (Benamati & Rajkumar, 2002) proposed an application of the technology acceptance model (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989) as a basis for investigating AD outsourcing decision making. The model also proposed risk, prior outsourcing relationships, and an organization's external environment to be important antecedents to decision-maker perceptions and hence important factors in AD outsourcing decisions (Benamati & Rajkumar, 2002).

The goal of this research is to empirically test and validate that model as a basis for further study and shed new light on factors that influence AD outsourcing decisions. The following section reviews the proposed model of outsourcing acceptance and develops hypotheses from it. The methodology used and findings from an empirical validation of that model are then explained. Finally, implications of both the results and the model for future research are discussed. No other research has empirically applied TAM in this way. Nor has there been empirical testing of the influence of these three antecedent factors on the decision to outsource AD.

THEORETICAL BASIS FOR THE RESEARCH MODEL AND HYPOTHESIS

TAM states that users' perception of the usefulness of a technology, defined as the degree to which a person believes that using the technology will enhance his or her job performance, and ease of use, defined as the degree to which a person believes that using the technology will be free of effort (Davis, 1989), directly affect the users' attitude about and hence their intention to use the technology. These two perceptions also moderate the effects of antecedent constructs on the decision to use the technology.

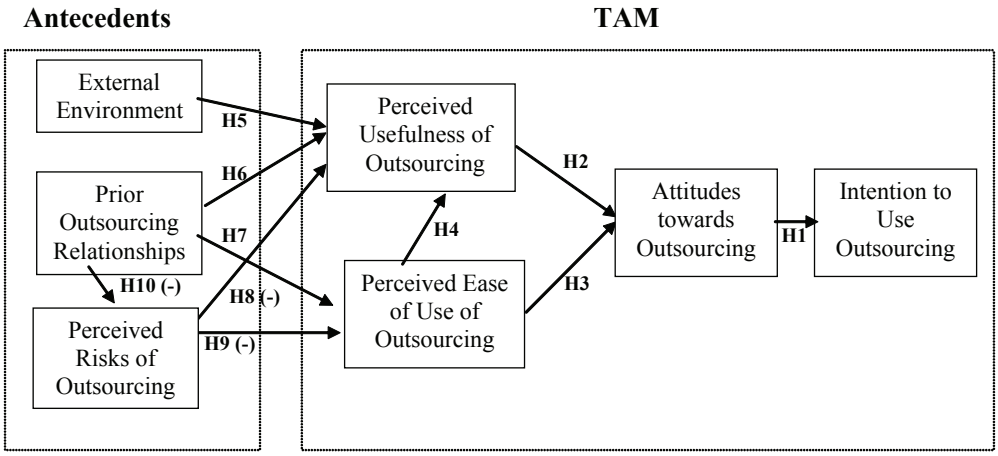
The AD outsourcing acceptance model (Benamati & Rajkumar, 2002) that is the focus of this study, shown in Figure 1, illustrates TAM constructs, outsourcing decision antecedent constructs, and posited relationships among the constructs. It proposes that TAM constructs are applicable to the acceptance of AD outsourcing. The TAM constructs and interrelationships are applied consistently with previous TAM research (Davis et al., 1989; Mathieson, 1991; Karahanna, Straub, & Chervany, 1999). Decision-maker perceptions of the usefulness, defined as the degree to which the decision maker believes that AD outsourcing will enhance the performance of the IT group, and ease of use, the degree to which the decision maker believes that AD outsourcing will be free of effort, are posited to influence their attitude about AD outsourcing which in turn affects their intention to do it. Consistent with TAM, the model proposes that a decision-maker positively inclined towards outsourcing is more likely to have intentions to outsource.

Many organization level decisions are ultimately made by an individual within the organization. IT managers most often prepare sourcing evaluations (Dibbern, Goles, Hirschheim, & Jayatilaka, 2004) and IT sourcing decisions elevate to the CIO, CFO, and CEO levels in organizations (Kakbadse & Kakabadse, 2002). A study of 160 French and German companies found the decision to outsource IT was made by an individual executive in 90% of the French and 75% of the German organizations studied (Barthelemy & Geyer, 2001).

The studies indicate most IT outsourcing decisions are organizational decisions primarily made by individuals. The unit of analysis in prior TAM research has predominantly been individual adoption of a specific technology. Recent studies apply TAM to organizational level adoptions decisions by owners or executives in small and medium sized enterprises (SME) and more general technology categories such as e-commerce (Granden & Pearson, 2004) or having a Web presence (Riemenschneider, Harrison, & Mykytyn, 2003). Since AD outsourcing is a solution to a general technology problem, TAM constructs and relationships may be applicable to high level decision-makers' acceptance of AD outsourcing.

Furthermore, TAM is rooted in the theory of reasoned action (Azjen & Fishbein, 1980) and other research has drawn on attitude based choice theory rooted in the theory of reasoned action to

Figure 1. Outsourcing acceptance model



study organizational level decisions. Mykytyn and Harrison (1993) studied the acceptance of strategic information systems by senior management and Candel and Pennings (1999), the choice of financial services by entrepreneurs. This provides further support for organizational level decision makers as a unit of analysis.

Figure 1 also illustrates the hypotheses tested in this study. Hypotheses one through four stem directly from the established TAM relationships. It is hypothesized that these relationships will hold in the AD outsourcing decision context as well. Hence, it is hypothesized that:

H1: *Decision maker attitude toward outsourcing AD positively affects their intention to use it.*

H2: *Decision maker perception of the usefulness of AD outsourcing positively affects their attitude towards it.*

H3: *Decision maker perception of the ease of use of AD outsourcing positively affects their attitude towards it.*

H4: *Decision maker perception of the ease of use of AD outsourcing positively affects their perception of its usefulness.*

The model also proposes the external environment, prior outsourcing relationships, and the perceived risk of outsourcing AD as antecedents to decision maker perceptions of AD outsourcing. Each is proposed to affect one or both of the TAM perception variables. Support for the influence of these antecedents on outsourcing decisions exists in prior literature.

A firm's external environment plays a role in decision-making (Goll & Rasheed, 1997). A dynamic, competitive, or uncertain environment can lead firms to focus on core competencies and outsource others (Slaughter & Ang, 1996). As hypercompetition becomes an unavoidable way of life in many industries (D'Aveni, 1994), IT plays a bigger and bigger role in achieving and sustaining competitive advantages. Furthermore, environmental change prompts organizations to maintain flexible organizational structures (Burns & Stalker, 1961; Perrow, 1970; Thompson, 1967; Woodward, 1965). Outsourcing provides flexibility and offers a way to adjust organizational boundaries in response to pressures from the environment (Lonsdale & Cox, 2000). For example, the critical contingencies that arise due to stiff competition were found to influence IT outsourcing decisions in the banking industry (Ang & Cummings, 1997). This provides support for the fifth hypothesis in the model.

H5: *A more competitive external environment positively affects decision maker perception of the usefulness of AD outsourcing.*

The importance of the client supplier relationships has received increasing attention in the outsourcing literature. Organizations and their outsourcing vendors have become more tightly coupled (Lee, Huynh, Chi-wai, & Pi, 2000) and long term partnerships are more appropriate (Nam, Rajagopalan, Rao, & Chaudjury, 1996; Saunders, Gabelt, & Hu, 1997; Mazzawi, 2002). Some outsourcing arrangements form as strategic alliances with deep levels of interdependence (Lacity & Willcocks, 1998; King, 2001) and the ability to build a trusted partnership and avoid relational trauma is imperative for success (Kern et al., 2002). It becomes critical to consider outsourcing as the management of relationships with service providers as opposed to simply managing contracts for IS commodities (Kishore, Rao, Nam, Rajagopalan, & Chaudhury, 2003). A recent survey of 700 IT professionals indicates that reliability and trust in the outsourcing vendor were the two most important factors in selecting an outsourcing vendor (Gareiss, 2002). Surprisingly, these two relationship qualities ranked above more traditional selection criteria such as cost and technical skills. Whitten and Leidner (2006)

found that for varying perceptions of product and service quality (high, low or poor), poor relationship quality has caused the decision to backsource or bring application development back in-house. The quality of the outsourcing relationship is clearly important (Lee & Kim, 1999) as these relationships are becoming mission critical (Kern & Willcocks, 2002).

From a decision making perspective, early outsourcing research predominantly overlooked the fact that many outsourcing decisions are not independent decisions but instead are based on prior outsourcing experiences (Nam et al., 1996; Lee et al., 2000). Past marketing research into customer-service provider relationships found that customer satisfaction with prior experiences with a provider affected their loyalty to that provider and the strength of the relationship increased with the length of prior experience (Bolton, 1998). Likewise, prior outsourcing experiences certainly influence follow-on outsourcing decisions. The outsourcing acceptance model posits that prior outsourcing relationships will influence decision maker perceptions about outsourcing's usefulness and ease of use as stated in hypotheses six and seven.

H6: *Positive prior AD outsourcing relationships positively affect decision maker perception of the usefulness of AD outsourcing.*

H7: *Positive prior AD outsourcing relationships positively affect decision maker perception of the ease of use of AD outsourcing.*

Risk is also an important factor in the AD outsourcing decision (Earl 1996; Aubert, Patry, & Rivard, 1998; Ketler & Willems, 1999). Risk, if ignored, leads to undesirable consequences, such as increased likelihood of project failure (Lyytinen, Mathiassen, & Popponen, 1998; Bahli & Rivard, 2005). IS managers may perceive outsourcing to reduce risk because it can provide skills the organization lacks to develop a particular application. However, outsourcing introduces many new risks such as hidden costs, lack of proper skills or infrastructure to manage the engagement, staff morale problems, and loss of control to or key dependence on a third party (Ketler & Walstrom, 1993; Hurley & Schaumann, 1997; Smith, Mitra, & Narasimhan, 1998; Barthelemy, 2001). Offshore outsourcing adds many additional challenges and risks to the outsourcing engagement (Ramarapu, Parzinger, & Lado, 1997). For example, the project team is, by definition, virtual and must be managed across time, distance, and perhaps even borders or oceans. Although some virtual organizations succeed, the value of virtual organizations has been oversold and more fail than succeed (Chesbrough & Teece, 2002).

Perceived risk has been shown to inhibit system or product evaluation and adoption in e-service settings (Featherman & Pavlou, 2003). That study also provided strong empirical evidence that perceived risk adversely influences perceived usefulness. In an AD outsourcing context, perceived risk can be expected to negatively influence the perceived usefulness of outsourcing. Hypotheses eight states this expectation.

H8: *Decision maker perception of the risk of AD outsourcing negatively affects their perception of the usefulness of AD outsourcing.*

The risks associated with outsourcing highlight the need to outsource in the right way (Ross & Westerman, 2004). When risk is perceived, users introduce standard risk management mechanisms such as risk assessment, and developing risk mitigation plans to handle the perceived risk. Contracts for example, are one mechanism used to effectively manage the outsourcing relationship and provide for early termination, in case of underperformance (Osei-Bryson & Ngwenyama, 2006). The outsourcer also typically sets up an organizational unit to coordinate interactions between its information technology staff and the vendor as well as monitor the vendor's performance. Users

must pay close attention to coordination in the early stages of the AD outsourcing projects so that costly adjustments to the coordination mechanisms do not occur later (Sabherwal, 2003). This additional effort to manage risks introduces a burden on the user to invest more time and effort in governance, oversight, and coordinating mechanisms, reducing the ease-of-use of outsourcing. Hence, this leads to the hypotheses:

H9: *Decision maker perception of the risk of AD outsourcing negatively affects their perception of the ease of use of AD outsourcing.*

Today's outsourcing relationships involve strategic alliances with shared risk between the provider and the purchaser of the outsourcing services (Lacity & Willcocks, 1998; Kishore et al., 2003). Just as good prior relationships should increase perceptions of ease of use and usefulness, it would be expected that positive past experiences would reduce the perception of risk associated with outsourcing. This expected inverse relationship forms the basis for a final hypothesis.

H10: Positive prior AD outsourcing relationships negatively affect decision maker perception of the risk of AD outsourcing.

METHODOLOGY

A survey instrument was implemented to empirically test the model and hence, the applicability of TAM and the influence of the antecedent variables. Most prior outsourcing studies applied more qualitative or case study research. Very few studies employed quantitative methods. This research is the first to employ a quantitative instrument to study the applicability of TAM and one of only a few to quantitatively examine antecedents to outsourcing decision making.

Instrument Development

The instrument items used to operationalize the constructs in Figure 1 were all derived from past research. All questions used a 1 to 7 scale where 1 meant "strongly disagree" and 7 meant "strongly agree."

The items for the four TAM constructs are revisions of items from previously validated TAM instruments (Agrawal & Prasad, 1999; Hu, Chau, Liu Sheng, & Yan Tam, 1999; Venkatesh & Davis, 2000). The items were reworded to change the focus from systems to application development outsourcing. For example, the TAM intention to use item "Given that I have access to the system, I predict that I would use it" became "Given that I have access to an outsourcer for applications development I predict that I would use them." These items were applied to test the TAM hypotheses (H1-H4).

Consistent with previous instruments applying TAM to organizational level adoption decisions (Grandon & Pearson, 2004), the items for ease of use focused on the decision maker's perception of their own ability to use outsourcing. Grandon and Pearson (2004) operationalized perceived usefulness as a mix of the decision maker's perception of the usefulness to themselves and to the organization. For example, "Using e-commerce would improve my job performance" and "Using e-commerce would enable my company to accomplish specific tasks more quickly" were used. For consistency, all usefulness items in the developed instrument addressed the usefulness of outsourcing to the organization.

The items for external environment and prior relationships originated from instruments used in marketing research. To measure the competitive nature of the environment, items from Industruct (Pecotich, Hattie, & Peng Low, 1999), an instrument developed to measure Porter's (1980) five competitive forces model were adapted. Only items from intensity of rivalry defined as "the

extent to which firms in this industry frequently and vigorously engage in outwardly manifested competitive actions and reactions in their search for competitive advantage in the marketplace" (Pecotich et al., 1999) were applied. That study found that rivalry was the strongest force of the five. Competitive rivalry is also probably the one most directly applicable to help test hypothesis five.

Many marketing studies have measured dimensions of relationship quality. The items for measuring relationship quality used here were drawn from two separate marketing instruments. This was done to tap into a representative set of relationship quality dimensions that may be applicable to outsourcing relationships. The first dimension adapted was relational norms (Heide & John, 1992). Relational norms allow both buyer and supplier to judge whether each party's actions conform to established standards (Ivens, 2006). The measures tap into three aspects of the relationship norms; flexibility—the expectation of a willingness of the parties to be adaptable to changing circumstances, information exchange—the expectation that a proactive exchange of useful information will occur, and solidarity—the expectation that both parties place a high value on the relationship.

Trust is also commonly identified as an important aspect of relationship quality (Crosby, Evans, & Cowles, 1990; Moorman, Zaltman, & Deshpande, 1992; Morgan & Hunt, 1994; Rindfleisch, 2000; Ulaga & Eggert, 2004; Huntley, 2006). Rindefleish's (2000) five item scale for organizational trust, which he defined as "… confidence in an exchange partner's reliability and integrity" was adapted.

This combination of 15 measures adequately represented the dimensions of relationship quality from an outsourcing perspective. These measures were applied to test hypotheses six, seven, and ten.

Established measures for outsourcing risk were not found in prior research and hence were developed from outsourcing risks identified by Elmuti and Kathawala (2000). This was the most complete list that was found and is applied to explore risk factors and test the last three hypotheses. Table 1 details the number and the source of survey items for each construct in the proposed framework.

Instrument Pretest

A pretest of the instrument was conducted with two IT academicians experienced in survey development, three IT executives who have outsourced applications development, and two executives from application development outsourcing providers. The pretest was done to ensure that the survey was clear and concise, and that items portrayed their intended meaning. Feedback was also sought on the length of the survey, its overall appearance, and how each participant would react to receiving it in the mail. Comments and suggestions were used iteratively to revise the survey.

During each pretest, one of the authors met with each of the participants individually and discussed the purpose of the survey. The subjects were asked to complete the survey. They were also asked to suggest improvements and to identify anything not clear to them. After completion of the survey, the attending author clarified and recorded subject feedback and suggestions.

The comments of each participant were incorporated before meeting with the next participant and the pretest iterated until all clarity issues in the survey were flushed out. The pretest resulted in substantial improvement in the clarity of the survey definitions and items. It also resulted in the addition of one ease of use item—using application development outsourcing makes it easier to share risk with the vendor. The Appendix lists all the survey items along with the instructions to subjects.

Table 1. Source of survey items

Construct	Prior Study Factor	Number of Items	Source
Intention to Use	Intention to Use	5	Venkatesh and Davis (2000) Agrawal and Prasad (1999) Hu et al. (1999)
Attitude	Attitude	4	Agrawal and Prasad (1999) Hu et al. (1999)
Perceived Usefulness	Perceived Usefulness	9	Davis (1989) Venkatesh and Davis (2000)
Perceived Ease of Use	Perceived Ease of Use	5	Venkatesh and Davis (2000)
External Environment	Competitive Rivalry	9	Pecotich et al. (1999)
Prior Relationships	Relational Norms	10	Heide and John (1992)
	Trust	5	Rindefleisch (2000)
Outsourcing Risks		18	Elmuti and Kathawala (2000)

Table 2. Subject organization industries

Industry	Number	Percentage
Finance	20	12.50%
Other	19	11.88%
Education	18	11.25%
Manufacturing	18	11.25%
Consulting	15	9.38%
Government	14	8.75%
Communication	9	5.63%
Health Care	8	5.00%
Transportation	7	4.38%
Insurance	6	3.75%
Systems Integrator	5	3.13%
Utilities	4	2.50%
Marketing	4	2.50%
Software development	4	2.50%
Banking	3	1.88%
Publishing	2	1.25%
Construction	2	1.25%
Legal	2	1.25%

Data Collection

To implement the survey, a random sample of 3000 IT executives was drawn from subscribers to an IS journal focusing on enterprise application issues. The journal qualified subscribers based on their level in the organization and provided a randomized sample from the over 25,000 subscribers with the level of director or higher in their organizations.

Two mailings were done. The first contained a solicitation letter, the survey, and a postpaid return envelope. The letter also included the URL of an online version of the survey. The second mailing was a reminder card that also pointed to the online version. The IT executives provided a total of 160 usable responses.

Subjects' organizations represented a variety of industries. Table 2 summarizes them. The "other" category includes all industries represented by only one organization.

Subjects' demographics indicate they were indeed high level IT executives. They averaged 19.4 years of IS experience, 9.6 with their current employer. In addition, they managed on average 78 subordinates. All subjects also indicated they played significant roles in outsourcing decisions for their organizations.

Table 3. Subject organization size

Number of IT Professionals	Number of Subject Organizations	Reported IT Budget (Thousands)	Number of Subject Organizations
1-49	77	**Under $99**	5
50-99	13	**$100-$499**	22
100-249	30	**$500-$1,999**	29
250-499	16	**$2000-4,999**	18
500-999	5	**$5,000-9,999**	22
More than 1000	18	**More than $10,000**	56
Not reported	1	**Not reported**	8

Table 3 summarizes the size of the subjects' organizations in terms of number of IT professionals and IT budget. Subjects estimated that on average 13.2% of their IT budget was spent on application development outsourcing and 19.7% on all types of IT outsourcing. AD outsourcing decisions were being made in these organizations.

Response rates in surveys of executive level individuals are often low (Pincus, Rayfuekdm, & Cozzens, 1991; Baruch, 1999) due to the numerous demands on their time. Many executives have buffer systems in place to control the receipt of requests for information such as surveys (Cycyota & Harrison, 2002). Subject organizations that are small exacerbate the low response rate problem (Dennis, 2003). Not unexpectedly, the response rate of 5.33% was low. Low response rates can introduce response bias. However, the absence of differences in the responses received at different times would be consistent with the claim that response bias was not present (Anderson & Gerbing, 1988). The responses for all of the factors and numeric demographic variables collected were tested for responses received before and after the second mailing. None of the t-tests (continuous variables) or chi-squared tests (categorical variables) showed responses to be significantly different. Hence, response bias was not found.

DATA ANALYSIS

The data analysis proceeded through two phases. The first phase examined the applicability of TAM to outsourcing decision making and the second the influence of the three antecedents on decision maker beliefs about outsourcing. The following two sections discuss these phases.

The Applicability of TAM

The TAM analysis proceeded through two steps. The first employed exploratory factor analysis (EFA) techniques to establish the validity of the instrument and identify the coping mechanism categories (Hatcher, 1994; Stevens, 1996). The second used simple linear regression to test the TAM hypotheses in the context of AD outsourcing.

The EFA used the principle factor method with promax oblique rotation. Oblique rotation is suggested when factors are thought to be correlated factors (Harman, 1976; Hatcher, 1994). The factors are hypothesized to interrelate (in fact, the data later showed that each resulting factor correlated with at least one other factor at .24 or higher). Based on the prior expectation of four TAM factors and the percent of variance criterion (Hatcher, 1994) with a five percent cutoff, four factors variables were retained.

In the factor analysis items PU2, PU8, and IN5 (see the Appendix) cross loaded onto the attitude construct, indicating multidimensionality in these measures. All three were dropped. Additionally, PU1, PU5, and EOU1 did not load above the recommended .40 cutoff on their factors and were also dropped. All remaining items loaded on their expected constructs. The constructs all had Cronbach alphas of .77 or higher, well within recommended thresholds (Nunnally, 1967). This indicated the reliability of the instrument. Table 4 presents the descriptive statistics for the analysis including the mean factor scores.

The second step in this analysis employed simple linear regression to test the TAM research hypotheses (H1 through H4). The regression results illustrated in Table 5 indicate that all four hypotheses were strongly supported.

The Effects of the Antecedents

The same two steps were followed to analyze the effects of the three antecedents, the external environment, prior outsourcing relationships, and the perceived risk of outsourcing. An EFA was done including all 42 antecedent items. The expectation was that three factors would emerge. However, five

Table 4. Final results of TAM exploratory factor analysis

Item	Attitude Towards Outsourcing	Perceived Usefulness of Outsourcing	Intention to Use Outsourcing	Perceived Ease of Use of Outsourcing
AT2	**.90**	.03	-.07	-.02
AT3	**.79**	.08	.09	-.13
AT1	**.77**	-.09	.09	.11
AT4	**.62**	-.08	.05	.17
PU4	-.13	**.80**	.05	.01
PU7	.07	**.66**	-.13	.06
PU3	.12	**.63**	.14	-.14
PU9	.28	**.55**	.09	.02
PU6	-.11	**.49**	.09	.06
IN2	-.02	-.01	**.95**	.01
IN1	.02	-.01	**.91**	.01
IN3	.19	.15	**.48**	.05
IN4	.17	.25	**.41**	-.04
EOU2	.04	.07	-.04	**.75**
EOU1	-.10	-.11	.03	**.67**
EOU3	.16	.21	.00	**.60**
EOU4	.26	-.01	.07	**.46**
Alpha	.87	.82	.87	.77
Eigenvalue	6.833	1.564	0.832	0.688
Percent of Variance Explained	71.0	16.3	8.7	7.2
Mean	4.25	5.12	4.72	3.23
Std. Dev.	1.16	0.96	1.19	1.09

factors accounted for more than 5% of the variance in the data and thus were retained. The risk items loaded onto three separate factors accounting for the two additional factors.

Five items were dropped in subsequent runs. Items EN9, RSK7, RSK15, and RSK17 did not load above .40 on their respective factors and REL9 cross loaded onto one of the risk factors. All remaining items loaded on their expected constructs. The constructs all had Cronbach alphas above .73 indicating the reliability of the instrument. Table 6 presents the descriptive statistics for the analysis.

The authors named the three risk factors: project management risk, relationship risk, and employee risk based on an interpretation of the concepts embodied by the items in each. These names are reflected in Table 6. Table 7 explicitly defines these three sub-dimensions of Risk in terms of those items.

To test hypotheses H5 through H10, again simple linear regression was employed. Due to the multiple sub factors of perceived risk of outsourcing, hypotheses H8, H9, and H10 were replicated as H8a, H8b, H8c, and so forth, to represent project management risk, relationship risk, and employee risk respectively. Table 8 summarizes the results. Support was found for 6 of the 12 hypotheses. The effect of prior relationships on perceived ease of use (H6, $p<.001$) and perceived usefulness (H7, $p<01$) suggest it to be an important antecedent to outsourcing decisions. The risk factors' inverse relationships with the other factors in the model were partially substantiated. Results indicated that project management risk inversely affected perceived ease of use (H9a, $p<.01$), employee risk inversely influenced perceived usefulness (H8a, $p<.05$), and prior relationships negatively affected relationship risk (H10b, $p<.01$). Surprisingly, employee risk had a positive affect on perceived ease of use (H9c, $p<.01$).

Table 9 summarizes the results of all the hypotheses tests. Six of the first seven hypotheses were supported. Mixed support was found for the three risk hypotheses.

The variance inflation factors of the independent variables in the tested models were all less than two indicating multicollinearity was not a problem in the data collected (Stevens, 1996). Additionally, Harman's single method test failed to demonstrate common method variance was a problem (Podsakoff & Organ, 1986). The two factor analyses produced neither a single factor nor one general factor that accounted for the majority of the variance and each factor accounted for more than the viable cut-off of 5% (Hatcher 1994).

DISCUSSION

The use of outsourcing is rapidly expanding. It is even growing outside the realm of IT outsourcing. Outsourcing decisions are strategically important to organizations. While much research has focused on IT outsourcing decisions, little has done so empirically. By empirically focusing on application development outsourcing decisions, this research has made several significant contributions to this body of knowledge.

Table 5. TAM hypotheses linear regression results

Dependent Variable	R^2	F-Value (p-value)	Independent Variable (Hypothis)	T value (P-value)	Estimate
Intention to Use Outsourcing	.37	93.44 (<.0001)	AT (H1)	9.67 (<.0001)	.6317
Attitude Towards Outsourcing	.45	61.95 (<.0001)	PU (H2) PEOU (H3)	7.11 (<.0001) 5.59 (<.0001)	.4414 .3794
Perceived Usefulness of Outsourcing	.12	20.86 (<.0001)	PEOU (H4)	4.57 (<.0001)	.3769

Table 6. Final results of antecedent exploratory factor analysis

Item	Relationship	Environment	Project Mgt. Risk	Relationship Risk	Employee Risk
REL11	**0.76**	-0.07	0.17	-0.07	-0.05
REL4	**0.74**	0.00	0.06	-0.03	-0.10
REL7	**0.68**	-0.19	-0.11	0.05	-0.03
REL10	**0.67**	0.10	-0.07	0.12	-0.12
REL13	**0.65**	-0.04	0.11	-0.12	0.14
REL1	**0.65**	-0.23	-0.09	0.05	0.04
REL8	**0.65**	0.06	0.26	-0.17	0.02
REL3	**0.64**	0.18	-0.04	-0.01	-0.11
REL2	**0.63**	0.16	-0.08	-0.03	-0.15
REL14	**0.58**	0.09	-0.08	-0.02	0.10
REL6	**0.56**	0.14	0.03	-0.05	-0.08
REL15	**0.54**	-0.02	-0.21	0.24	0.23
REL5	**0.51**	-0.06	-0.01	0.00	0.08
REL12	**0.51**	-0.03	0.01	0.02	0.08
EN6	0.03	**0.81**	0.10	0.03	0.00
EN3	0.00	**0.79**	0.05	0.05	-0.01
EN8	-0.06	**0.74**	0.02	-0.03	0.09
EN1	-0.06	**0.73**	0.06	0.00	-0.01
EN5	0.02	**0.73**	-0.17	0.18	-0.04
EN2	0.01	**0.71**	0.00	0.02	-0.04
EN7	0.02	**0.67**	-0.03	-0.09	0.08
EN4	0.08	**0.41**	0.04	-0.02	0.11
RSK4	-0.09	0.09	**0.70**	0.06	-0.07
RSK3	-0.05	0.09	**0.59**	-0.12	0.10
RSK5	0.13	0.04	**0.54**	0.13	0.03
RSK11	-0.06	-0.07	**0.50**	0.12	0.11
RSK16	-0.04	-0.27	**0.46**	0.12	-0.07
RSK1	0.07	0.23	**0.45**	-0.01	-0.02
RSK14	0.06	0.07	-0.13	**0.74**	0.04
RSK9	0.01	0.04	0.09	**0.72**	0.00
RSK8	-0.15	0.03	0.11	**0.55**	-0.18
RSK18	-0.10	0.07	0.07	**0.53**	0.00
RSK13	0.07	-0.24	0.31	**0.45**	0.03
RSK12	0.07	0.00	0.27	**0.43**	0.14
RSK2	0.07	0.02	-0.01	-0.10	**0.82**
RSK6	0.05	0.05	0.06	0.05	**0.78**
RSK10	-0.13	0.07	0.04	0.04	**0.77**
Alpha	.89	.87	.73	.76	.86

continued on following page

Table 6. continued

Eigenvalue	6.402	5.252	3.487	1.935	1.435
Percent of Variance Explained	26.1	21.4	14.2	7.9	5.8
Mean	4.86	4.04	4.70	4.64	4.42
Std. Dev.	0.87	1.30	0.96	1.07	1.50

Table 7. Definitions of the risk sub-dimensions

Risk Sub-Dimension	Definition
Project Management Risk	Environmental uncertainties or the lack of, management skills, control mechanisms, infrastructure, or high level support for the outsourcing effort.
Relationship Risk	Risks associated with vendor relations including vendor's lack of knowledge of the business, contract length, flexibility in the relationship, meeting schedules, and maintaining security and confidentiality of information shared.
Employee Risk	Fear of layoffs and the accompanying risk of lower employee morale and performance due to outsourcing.

Table 8. Antecedent hypotheses linear regression results

Dependent Variable	R^2	F-Value (P-value)	Independent Variable	T value (P-value)	Estimate
Perceived Usefulness of Outsourcing	.26	7.57 (<.0001)	PEOU (H4) EN (H5) REL (H6) PrjMgtRISK (H8a) RelRISK (H8b) EmpRISK (H8c)	3.61 (.0004) 1.16 (.2486) 2.95 (.0037) 1.21 (.2267) -1.37 (.1736) -2.53 (.0127)	.3441 .0418 .0983 .0921 .0863 .2363
Perceived Ease of Use of Outsourcing	.19	8.10 (<.0001)	REL (H7) PrjMgtRISK (H9a) RelRISK (H9b) EmpRISK (H9c)	4.25 (<.0001) -2.63 (.0094) 0.05 (.9624) 3.22 (.0016)	.1211 -.1770 .0027 .2632
Project Management Risk	.02	2.19 (.1409)	REL (H10a)	-1.48 (.1409)	-.0574
Relationship Risk	.05	6.91 (.0095)	REL (H10b)	-2.63 (.0095)	-.1127
Employee Risk	.01	1.07 (.3029)	REL (H10c)	-1.03 (.3029)	-.0316

First, it contributed by empirically validating that the technology acceptance model has application to organizational level decision makers. Many organizational level decisions are ultimately made or strongly influenced, by a single individual. This study found that for outsourcing decisions, TAM may apply. Perceptions of the usefulness and ease of use of outsourcing strongly influence decision makers' attitudes about and hence their intention to use AD outsourcing. This finding perhaps indicates that TAM is applicable in the study of other organizational level decisions. It is interesting the note the striking difference in the means factor scores for usefulness (5.12) and ease of use (3.23). There is general agreement in the sample that AD outsourcing is useful, but not so easy to do.

Table 9. Hypotheses testing summary

Hypothesis	Supported	Significance
H1: *Decision maker attitude toward outsourcing AD positively affects their intention to use it.*	**Yes**	***
H2: *Decision maker perception of the usefulness of AD outsourcing positively affects their attitude towards it.*	**Yes**	***
H3: *Decision maker perception of the ease of use of AD outsourcing positively affects their attitude towards it.*	**Yes**	***
H4: *Decision maker perception of the ease of use of AD outsourcing positively affects their perception of its usefulness.*	**Yes**	***
H5: *A more competitive external environment positively affects decision maker perception of the usefulness of AD outsourcing.*	**No**	
H6: *Positive prior AD outsourcing relationships positively affect decision maker perception of the usefulness of AD outsourcing.*	**Yes**	**
H7: *Positive prior AD outsourcing relationships positively affect decision maker perception of the ease of use of AD outsourcing.*	**Yes**	***
H8: *Decision maker perception of the risk of AD outsourcing negatively affects their perception of the usefulness of AD outsourcing.*	**PrjMgtRisk—No RelRisk—No EmpRisk—Yes**	*
H9: *Decision maker perception of the risk of AD outsourcing negatively affects their perception of the ease of use of AD outsourcing.*	**PrjMgtRisk—Yes RelRisk—No EmpRisk—Yes**	** (**) Reversed
H10: *Positive prior AD outsourcing relationships negatively affect decision maker perception of the risk of AD outsourcing.*	**PrjMgtRisk—No RelRisk—Yes EmpRisk—No**	**

*** (p<.001) ** (p<.01) * (p<.05)*

Useful information can be garnered from the items that were dropped in the factor analysis of the TAM items. Most of them were from the perceived usefulness construct. It appears that the usefulness of AD outsourcing to improve the IS function's effectiveness, improve the quality of IS applications, and reduce costs is not recognized in the subject organizations surveyed. Perhaps this finding indicates this is not what is happening. Recent research has asserted that outside support may not be the panacea that it is touted to be (Benamati & Lederer, 2001).

Empirical support was also found for two of the three hypothesized antecedents to decision maker perceptions, prior outsourcing relationships and perceived risk of outsourcing. Prior outsourcing relationships strongly influence both perceptions. While this seems intuitive, perhaps this study provides the motivation needed for both providers and receivers of outsourcing to attend to existing relationships more carefully. Positive prior relationships increase decision maker perception of outsourcing AD as well as attenuate relationship risk, one of the dimensions of risk identified in the study.

AD outsourcing decisions are made in the face of risk. Categorizing the risks allows managers to select appropriate management tools and actions for each type of risk (McFarlan, 1981; Jurison, 1995). Thus, the three dimensions of risk empirically identified in this study employee, project management, and relationship risk provide neces-

sary knowledge for the purpose of outsourcing decision making. The individual items in each category provide additional knowledge. Prior academic research and popular practitioner press have identified these potential hazards faced when outsourcing. The current empirical research more firmly establishes their relevance to the context of AD outsourcing decisions.

Employee risks such as decreased morale (Antonucci, Lordi, & Tucker III, 1998; Kliem, 1999; Lonsdale & Cox, 2000) or performance (Garaventa & Tellefsen, 2001) are often cited as issues faced in the outsourcing process. Managers and their employees are interdependent on each other for success. This goes beyond any written contract stating responsibilities and remuneration for a job well done. Employees develop individual perceptions or psychological contracts of what they owe to their employers and what their employers owe to them (Robinson, 1996). A breach of this contract in the eyes of the employee negatively affects employee performance (Robinson, 1996; Garaventa & Tellefsen, 2001). Outsourcing can be viewed as such a breach and has actually been described as a betrayal of workers (Gordon, 1996). This study found that employee risk negatively impacts the perceived usefulness of outsourcing and hence the outsourcing decision.

Proper management of the outsourcing engagement is also imperative for success. "Outsourcing does not eliminate the need to manage the function. Rather, it creates a situation requiring managers to utilize a different set of skills" (Garaventa & Tellefsen, 2001). A recent survey of 116 companies found that the struggle to manage the outsourcing process was a key reason for dissatisfaction with outsourcing arrangements (PA Consulting Group, 2003). Lacity and Willcocks (1999) identified the lack of active management of the supplier and lack of maturity and experience of contracting for and managing the outsourcing arrangement as two of the main reasons for negative outcomes in IT outsourcing deals (Lacity & Willcocks, 1999). Furthermore, one often cited reason for outsourcing IT functions is inadequacies in the current IT organization's performance (Ketler & Walstrom, 1993; Lacity & Willcocks, 1998; Smith et al., 1998). "If the IT activity has been badly managed in the first place, will the IT managers be any better at managing an external provider?" (Earl, 1996). Clearly, project management risk is an issue and this study found it negatively affects decision maker perceptions of ease of use.

The third category of risk identified, relationship risk, stems from the risks involved when depending on a third party to deliver important products or services. Excessive contract length could lock the organization into a negative relationship (Kliem, 1999) in which they are held hostage by the vendor (Antonucci et al., 1998). Rigid outsourcing contracts, while intended to protect the buying organizations, might actually lead to less flexibility to take advantage of new technologies or react to changing business needs (Antonucci et al., 1998). Multiple studies have examined outsourcing contract parameters (Ketler & Walstrom, 1993; McFarlan & Nolan, 1995; Lacity & Willcocks, 1998; Kelter & Willems, 1999). Confidentiality and the proper care of sensitive data and business knowledge are now in the hand of a third party and must be protected (Jurison, 1995; Antonucci et al., 1998; Lonsdale & Cox, 2000). Another source of relationship risk is the vendor's ability to deliver (Jurison, 1995), especially without prior relationships with that vendor. It was found that positive prior relationships reduce the perception of relationship risks.

This research also found no support for the influence of the external environment on outsourcing decisions. The structured interviews in the model building study (Benamati & Rajkumar, 2002) found mixed responses about the importance of the external environment. Other studies report similar mixed responses. For example, Loh and Venkatraman (1992) found that outsourcing behavior of other organizations is a good indicator of outsourcing events, but Hu, Saunder, and Gabelt (1997) did not find corresponding effects. In

spite of assertions that competition may influence decision maker perceptions about outsourcing, this was not the case in the subject organizations in this study.

IMPLICATIONS FOR FUTURE RESEARCH

This research was the first empirically study of the application of TAM to the decision to outsource. The applicability of TAM as a basis for explaining the mediating effects of decision-maker attitude on organizational decision making is a major contribution of this study. The instrument developed here based on prior TAM research could provide a basis for other decisions made at this level. The decision-making processes for outsourcing other IT functions or entirely different technology decisions could be examined. Influential external variables for these alternative decisions could also be studied.

Additionally, the antecedents established in this research provide a basis for further study. This study identified prior relationships, employee risks, and project management risks as important to the AD outsourcing decision. Future research should look more closely at these to both validate and extend these findings. It might also be interesting to explore why increased perceptions of employee risk increased perceived ease of use for decision makers. Perhaps IT executives do feel that keeping employees on edge is good and helps ease the use of AD outsourcing. It is also possible that this result was due an anomaly of the sample or flaw in the measures. This finding is not unique to this study. A study of TAM and mobile commerce found, perceived risk positively influenced intention to use (Wu & Wang, 2005). They speculate that users are perhaps well aware of the risks, and weigh the benefits more than the risks. In either case, more research is required.

The antecedents' influences could also be examined for the outsourcing of other business processes. They could also be studied across organizations of different size, of different organizational structures, or in different industries. The R^2 values in Table 8 indicate that these are probably not the only antecedents to outsourcing decisions. The methodology applied here could be used to identify and study other important influential elements in outsourcing decisions. Finally, this study focused only on the decision to outsource. The antecedents identified here as influential to the decision most likely play significant roles in the outsourcing process itself. Future research could explore these relationships.

IMPLICATIONS FOR PRACTICE

Useful knowledge for practitioners also results from this study. Decision maker perceptions about outsourcing obviously influence their decisions. The identification of prior relationships and two of the three dimensions of risk: project management, employee, and relationship risk as strong influencers of these perceptions is useful knowledge to decision makers in both outsourcing customer and provider organizations.

Application development outsourcing providers should work to manage decision maker perceptions about relationship quality and relationship risks when trying to sell further business. For example, the study indicates that organizations seeking an AD outsourcing vendor are sensitive to the length of the outsourcing contract and the amount of industry knowledge the outsourcing vendor has. Both should play a role in the marketing strategy to win outsourcing contracts.

Outsourcing decision makers can learn from the experiences of others presented here. They should pay particular attention to the individual items from the risk antecedents identified as influential. Decision makers should also understand that the results indicate negative prior outsourcing experiences may predispose them to choose not to outsource in a future decision. While, this may indeed be the correct path, it may not.

LIMITATION

A limitation of this study is the low response rate, 5.33% of the executive decision makers surveyed. Response rates in surveys of executive level individuals are often low (Pincus, Rayfuekdm, & Cozzens, 1991; Baruch, 1999) due to the numerous demands on their time. Regardless, this limitation should be carefully addressed in similar future studies. Doing so will help to ensure the generalizability of the findings of future research.

CONCLUSION

The use of outsourcing application development is increasing. This study is the first to empirically validate the applicability of technology acceptance model to enhance the understanding of the decision to outsource application development. Outsourcing decision makers in organizations and outsourcing providers can glean useful insights from the results. Additionally, researchers can use this work as a platform for future research.

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APPENDIX

For the purpose of this survey, outsourcing vendors are defined as any organization external to your own to which you have in some way transferred responsibility for any type of application development efforts. This definition excludes contract workers.

Industry Environment

Please indicate your level of agreement with the following statements about the industry in which your organization operates.

EN1	In our industry, price cutting is a common competitive action.
EN2	In our industry, firms compete intensely to hold and/or increase their market share.
EN3	In our industry, competitive moves from one firm have noticeable effects on other competing firms and thus incite retaliation and counter moves.
EN4	In our industry, foreign firms play an important role in industry competition.
EN5	In our industry, firms have the resources for vigorous and sustained competitive action and for retaliation against competitors.
EN6	In our industry, price competition is highly intense (i.e., price cuts are quickly and easily matched).
EN7	In our industry, advertising battles occur frequently and are highly intense.
EN8	In our industry, appropriate terms used to describe competition are ”warlike,“ “bitter,” or ”cut- throat.”
EN9	In our industry, there is a diversity of competitors (i.e., competitors may be diverse in strategies, origins, personality, and relationships to their parent companies).

Potential Outsourcing Risk

Outsourcing applications development involves a level of risk to the organization requiring the application. To what level do you agree that each of the following is a concern when outsourcing application development in your organization?

RSK1	Inadequate training/skills needed to manage application development outsourcing
RSK2	Fear of job loss by employees due to projects being outsourced
RSK3	Unclear expectations/unclear objectives of outsourcing
RSK4	Inadequate control mechanisms on the outsourced project
RSK5	Uncertainties in the environment
RSK6	Decline in performance of in-house employees due to the project being outsourced
RSK7	Over emphasis on short term benefits of outsourcing
RSK8	Meeting and enforcing time schedules are problematic with outsourcing
RSK9	Security is harder to maintain on outsourced projects
RSK10	Decline in morale of employees due to outsourcing
RSK11	Lack of infrastructure to support outsourcing efforts
RSK12	Excessive length of outsourcing contract
RSK13	Lack of flexibility by you and/or vendor

RSK14	Confidentiality is harder to maintain on outsourced projects
RSK15	Fear of becoming dependent on the outsourcing vendor
RSK16	Inadequate high level management support for outsourcing
RSK17	Inadequate knowledge transfer back from the outsourcing vender
RSK18	Vendor's lack of knowledge of our business

Perceptions of Outsourcing

Please assess your level of agreement with the following statements relative to outsourcing applications development work in your organization.

PU1	Using applications development outsourcing improves the IS function's effectiveness.
PU2	Using applications development outsourcing improves the quality of IS applications.
PU3	Using applications development outsourcing allows the IS function to accomplish tasks critical to the organization.
PU4	Using applications development outsourcing allows the IS function to develop more systems than would otherwise be possible.
PU5	Using applications development outsourcing allows the IS function to reduce costs.
PU6	Using applications development outsourcing helps the IS function meet staffing goals.
PU7	Using applications development outsourcing allows the IS function to develop systems more quickly than would otherwise be possible.
PU8	Using applications development outsourcing makes it easier to perform IS functions
PU9	In general using applications development outsourcing is useful.
EOU1	I understand how to use outsourcing.
EOU2	Using outsourcing does not require a lot of mental effort.
EOU3	I find outsourcing to be easy to use.
EOU4	I find it easy to accomplish what I set out to do through outsourcing.
EOU5	Using application development outsourcing makes it easier to share risk with the vendor.
AT1	I like using application development outsourcing.
AT2	Outsourcing provides an attractive alternative to in house application development.
AT3	Using application development outsourcing is in general a good idea.
AT4	Using application development outsourcing creates a pleasant project environment.
IN1	Assuming I have an outsourcer for applications development, I intend to use them.
IN2	Given that I have access to an outsourcer for applications development I predict that I would use them.
IN3	I intend to increase my usage of application development outsourcing in the future.
IN4	I intend to use application development outsourcing as often as needed.
IN5	To the extent possible, I would use application development outsourcing frequently.

Outsourcing Relationships

If your organization has never outsourced application development work, please skip to the Demographic Information section.

Otherwise, please think about your organization's relationships with past outsourcing vendors and indicate your level of agreement with the following statements.

REL1	We generally trusted our vendors.
REL2	Flexibility in response to requests for changes was a characteristic of past relationships.
REL3	We kept each other informed about events or changes that might have affected the other party.
REL4	Both our vendors and us did not mind helping each other out.
REL5	If we were unable to monitor our vendors' activities, we trusted them to fulfill their obligations.
REL6	Both us and our vendors expected to be able to make adjustments in the ongoing relationships to cope with changing circumstances.
REL7	We trusted our vendors to carry out important project-related activities.
REL8	Problems that arose in the course of these relationships were treated by both us and our vendors as joint rather than individual responsibilities.
REL9	We were willing to let our vendors make important decisions without our involvement.
REL10	In these relationships, it was expected that any information that might have helped the other party would be provided to them.
REL11	Both our vendors and us were committed to improvements that benefited the relationship as a whole, and not only the individual parties.
REL12	When some unexpected situation arose, together with our vendors, we worked out a new deal rather than hold each other to the original terms.
REL13	We trusted our vendors/vendors to do things we could not do ourselves.
REL14	Exchange of information in these relationships took place frequently and informally, and not only according to a prespecified agreement.
REL15	It was expected that we and our vendors would share our proprietary information if it could help the other party.

This work was previously published in the Information Resources Management Journal, Vol. 21, Issue 2, edited by M. Khosrow-Pour, pp. 80-102, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 10
Testing for the Applicability of the TAM Model in the Arabic Context:
Exploring an Extended TAM with Three Moderating Factors

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ABSTRACT

The present study attempts to investigate the applicability of the TAM model in the Arab context and to extend TAM with three moderating/interacting human factors. Using a survey sample collected from 722 knowledge workers using desktop computer applications on a voluntary basis in Saudi Arabia, this study sought empirical support for testing the basic structure of TAM. Toward that, the study was successful as the structure of TAM holds well in the Saudi settings. This study also empirically examined an extended TAM by incorporating gender, age and educational level as moderators of the model's core relationships. Our findings emphasize that most of the key relationships in the model are moderated. Specifically, age moderates all the influences of computers usefulness and ease of use on attitudes and intention to use. However, gender and educational level only moderate the influence of ease of use on attitudes.Implications for management and practice of these findings are discussed.

INTRODUCTION

Automation via computerization and other related information technologies (IT) in today's organizations has expanded dramatically as one of the highest priorities and objectives of modern organizations. Previous research shows that IT has a perceived impact on the work, the individual, and the organization. While developing countries are increasingly deploying IT in recognition of its vital role to solve their developmental problems, studies show that many of their systems are under-

utilized (Anandarajan, Igbaria, & Anakwe, 2002). Financial loans for IT by the World Bank (2006) were in harmony with this direction achieving six times the growth rate of total bank lending and is present in 90% of bank's lending operations (Harris & Davison, 1999).

Although the provision of the technology is a necessary condition to attain the benefits that IT can bring, there is escalating evidence to suggest that this is not sufficient in itself. In fact, computer systems cannot improve organizational performance if they are not used (Davis, Bagozzi, & Warshaw, 1989). Resistance to computer systems by managers and professionals is a wide spread problem in the developed world (Davis et al., 1989; Hu, Chau, Sheng, & Tam, 1999; Venkatesh & Davis, 2000), let alone the developing countries. For a quarter of a century, researchers in the MIS field have frequently addressed the question "why interactive computer systems are sometimes not used by people who might benefit from them?" Unfortunately, the question still persists. Explaining user acceptance of new technology is often described as one of the most mature research areas in the contemporary information systems (IS) literature (e.g., Hu et al., 1999). As a result, the adoption and use of technology in organizational settings has become a topic of broad interest to researchers and practitioners in management and psychology worldwide.

In the study of IT implementations in organizations, there have been a proliferation of competing explanatory models of individual acceptance of IT. This study aims to extend our ability to explain individual acceptance and usage decisions in organizations. TAM is tailored to IS contexts, and was designed to predict IT acceptance and usage on the job. TAM has had a significant research history, with the vast majority of that research being conducted in developed countries (Burton-Jones & Hubona, 2005; Gefen et al., 2003; Lee, Kozar, & Larsen, 2003; Legris, Ingham, & Collerette, 2003; Liu & Ma, 2006). As we shift to a global economy with businesses becoming increasingly multinational companies (MNCs), the need to carry IT research to developing countries has increased (Niederman, Boggs, & Kundu, 2002). The globalization of businesses has highlighted the need for understanding the effectiveness of IS that span different nations and cultures (Niederman et al., 2002, Shin, Ishman, & Sanders, 2007). Multinational and trans-cultural organizations have a growing need to utilize IT to achieve economies of scale, coordinate global operations, and facilitate collaborative work across distributed locations and diverse cultures (Ives & Jarvenpaa, 1991).

With more globalization of economy and businesses, cultural differences in user evaluations of IS have become an important issue in the evaluation of computer systems. Cultural differences can make the difference between success and failure in the adoption and implementation of IS (Png, Tan, & Wee, 2001, Straub, Keil, & Bernner, 1997). This has resulted in more studies testing TAM in the developing world (Anandarajan et al., 2002; Hubona, Truex, Wang, & Straub, 2006; Mao & Palvia, 2006; McCoy, Everard, & Jones, 2005). However, studies testing TAM in the Arab world have been limited (Niederman et al., 2002; Rose & Straub, 1998; Straub, Karen, & Hill, 2001). Researchers in this area have questioned whether TAM will hold equally well across cultures.

Overseas subsidiaries of many MNCs are mainly in developing countries. These subsidiaries should adopt and use IT effectively similar to those in the subsidizer company to ensure business success. However, the majority of workers in those overseas subsidiaries are (or ought to be) national workers due to policies (like, Saudization) enforced by the host developing country. In Saudi Arabia, Saudization is a development strategy that seeks to replace foreign workers with Saudi nationals (Looney, 2004), as a part of a growing trend in policy for the Arab Gulf Cooperation Council (AGCC) countries to control the flow of foreign labor (Winckler, 1997). Foreign labor is being restricted as a result of reputed negative

economic and social ramifications of a large foreign resident population on Saudi nationals.

Hence, with the accelerating forces of globalization, and the increasing deployment of IT in developing countries, there exist compelling incentives to better understand the unique drivers of IT adoption in non-Western countries (Al-Gahtani, 2004; Anandarajan et al., 2002). The challenges of, and parameters for, successful IT adoption in developing countries differ significantly from those in developed countries, largely due to differing social and cultural contexts (Abdul-Gader 1999; Straub et al., 2001). In the case of Saudi Arabia, detailed and supportive national IT policies have been explicitly developed by the Saudi government. These policies address political, social, economic, and environmental aspects for promoting the adoption of IT (Malek & Al-Shoaibi, 1998). The success of these policies depends on how well the individual factors of IT adoption have been incorporated.

Hill, Loch, Straub, and El-Sheshai (1998) explored the characteristics of Arab individuals that affect IT adoption. They reported that social factors, including class and education, were key variables impacting the success of IT adoption. Gender, however, has a potential role particularly in a conservative environment. Additionally, the factor of age was important in influencing differences in IT adoption. Saudi Arabia's population is relatively young, with a median age of 21.28 in 2005, with 39.3% of the population under the age of 15 and with only 2.6% of the population aged 65 or above (Global Virtual University, 2006).

Saudi Arabia is a conservative country where Islamic teachings and Arabian cultural values are dominant. It exemplifies political and economic roles among Arabs and Muslims all over the world. Socio-cultural characteristics of Arab and Muslim societies differ from those of the West. Specifically, we speculate that there are social and cultural characteristics that impact IT adoption in the workplace. Particularly, we are concerned with the following question: Do socio-cultural characteristics, particularly those related to beliefs and attitudes, affect the intention to use IT among Saudi Arabian professional workers? Our methodology on testing this question probes whether specific characteristics of the Saudi people influence the success of IT adoption and whether these characteristics have differential ramifications for existing IT acceptance models established and tested in developed countries (Ein-Dor, Segev, & Orgad, 1992).

Accordingly, within this broad area of inquiry, the purpose of this study is to investigate the applicability of the TAM model in an organizational setting in the Arab culture and to extend TAM by introducing three user-related moderating (interacting) variables. It is intended that the findings of this research facilitate the development of policies and practices by organizations in developing countries that are effective in influencing technology acceptance and use. Findings of this study are also helpful to MNCs to accommodate the potential effects of these interacting (moderating) human factors in the context of new IT adoption and use in this part of the world.

BACKGROUND

In the following we shed light on the theoretical background of TAM and the role of moderating/interacting variables to reflect on three pertinent human factors and their potential differences in individual adoption and use of technology.

The Technology Acceptance Model

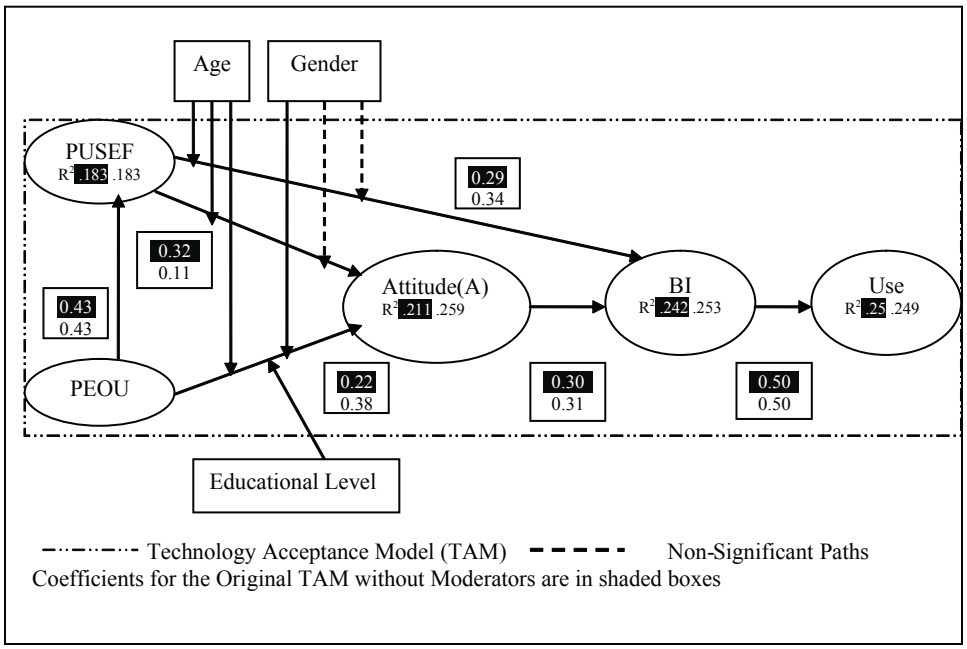
Of particular interest and relevance for the current research are social psychological theories of individual behavior, such as the theory of reasoned actions (TRA), on which TAM is based and has been used as a useful lens for looking at user beliefs and behavior (i.e., use). TAM, first published by Davis et al. (1989), continues to be the most applied theoretical model in the IS

field (Lee et al., 2003; Legris et al., 2003). Prior research has successfully applied TAM to new technology implementation, providing a strong evidence for its efficacy in predicting individual use and adoption of automated tools in the workplace (e.g., Al-Gahtani, 2001; Davis, 1989; Davis et al., 1989; Hu et al., 1999; Venkatesh & Davis, 2000; Venkatesh & Morris, 2000).

TAM postulates that two particular beliefs, namely perceived usefulness (PUSEF) and perceived ease of use (PEOU), are of primary relevance for computer acceptance behaviors (Davis et al., 1989; Igbaria, Zinatelli, Cragg, & Cavaye, 1997; Venkatesh & Davis 2000; Venkatesh et al., 2003). According to TAM, system usage is determined by the person's behavioral intention (BI) and BI is jointly determined by the person's attitude (A) toward using the system and PUSEF. Concurrently, A is jointly determined by PUSEF and PEOU. PUSEF is determined by PEOU. TAM is depicted in Figure 1.

PUSEF is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" while PEOU is defined as "the degree to which a person believes that using a particular system would be free of effort" (Davis, 1989, p. 320). Attitude toward using the system is defined as the degree of evaluative affect that an individual associates with using the target system in his or her job (Davis, 1993, p. 476). It refers to the person's general feeling, favorable or otherwise, for the use of the new technology. TAM conceptualizes individual perceptions of usefulness based on instrumentality as being strongly related to attitude toward technology use. BI are assumed to capture the motivational factors that influence a behavior; they are indications of how hard people are willing to try, of how much of an effort they are planning to exert, in order to perform the behavior (Ajzen, 1991). System usage has been the primary indicator of technology acceptance (Adams, Nelson, & Todd, 1992; Davis et al.,

Figure 1. Research conceptual model



1989; Igbaria et al., 1997; Straub, Limayem, & Karahanna, 1995; 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).

During the past two decades, the IS community considered TAM a parsimonious and a powerful theory (Lucas & Spitler, 1999; Venkatesh & Davis, 2000). Further supporting the notion of TAM's popularity, Lee et al. (2003) found that the first two TAM articles, by Davis (1989) and Davis et al. (1989) received 698 journal citations in the Social Science Citation Index (SSCI) by 2003. Extending the citation search further, more than 4,500 journal articles cite[1] one or both of the original TAM articles. TAM has been applied to different technologies (e.g., word processors, e-mail, WWW, GSS, Hospital IS) under different situations (e.g., time and culture) with different control factors (e.g., gender, organizational type, and size) and different subjects (e.g., undergraduate students, MBAs, and knowledge workers), leading its proponents to believe in its robustness. Currently, researchers in the IS field consider TAM one of the IS fields' own theories, and still put much effort into the study of research using this theory (Lee et al., 2003). In a critical review of TAM, Legris et al. (2003) conclude that TAM is a useful model, but has to be extended to include variables related to both human and social change processes. Hubona and Cheney (1994) and Taylor and Todd (1995) compared both TAM and TPB models and found that TAM offers a slight empirical advantage and is a much simpler, parsimonious, easier to use, and a more powerful model to explain users' technology acceptance.

TAM has received extensive empirical support for explaining behavior in both individual and organizational settings. However, recent meta-analytic evidence suggests that low explanations of variance were referred to as a major problem of TAM (Lee et al., 2003). Despite the impressive predictive power of TAM, a large proportion of the potentially explainable variance remains unaccounted for. Conner, Sheeran, Norman, and Armitage (2000) note that two ways to address this unexplained variance are through the inclusion of additional variables and moderator variables. The latter approach forms the basis of the current examination of TAM for technology adoption and use decisions in organizations.

TAM has been rarely extended with moderators. Venkatesh and Davis (2000) extended TAM to TAM2 and incorporated experience and voluntariness to moderate the SN-BI relationship in TAM while Venkatesh and Morris (2000) demonstrated that the primary TAM relationships (PUSEF-BI and PEOU-BI) are moderated by gender. Venkatesh et al. (2003) developed the UTAUT unified model of technology adoption, with constructs similar to the TAM, found a moderation pattern of gender and age similar to what is being suggested here among the TAM constructs. Ong and Lai (2004) used TAM to empirically examine gender differences in perceptions and relationships among dominants of e-learning acceptance. Recently, Morris, Venkatesh, and Ackermann (2005) formally investigated TPB for extension with gender and age as moderators while considering TAM as a competing model of technology adoption to draw parallels between TPB and TAM.

Moderating/Interacting Variables

User-centric approach practices that suggest that analysis must first gain a fundamental understanding of the user needs, outlook, and expectations is gaining a new thrust. IT project managers must prioritize users over other aspects of design (Tempkin, 2003). Underscoring the importance of this user-centric approach, the changing nature of today's workforce has significantly broadened the typical user base in organizations and has spawned recent research focusing on the importance of gender (e.g., Ahuja, 2002; Hoxmeier, Niew, & Purvis, 2000; Trauth, 2002; Woodfield, 2002) and age effects (e.g., Ford et al., 1996; Hubona

et al., 2006) on technology-related issues in the workplace.

Furthermore, a recent review of the literature by Morris et al. (2005) suggests that the role of moderators has been largely overlooked. Albarracin, Johnson, Fishbein, and Muellerleile (2001) and Conner et al. (2000) tested an extended theory of planned behavior (TPB) and contend that their work suggests that the interplay of gender and age alters the nature of key relationships in TPB. Morris et al. (2005) argue that their findings underscore the importance of including key theoretical moderators such as gender and age as key extensions to theoretical models (such as TAM) when applied to technology use.

As many have noted, gender and age are among the most fundamental groups to which individuals can belong and membership in such groups is likely to have a profound influence on individual perceptions, attitudes, and performance (Nosek, Banaji, & Greenwald, 2002). Therefore, studying the role that membership in these groups plays with respect to attitudes and beliefs about technology in the workplace is especially important today.

Moderators have been used to some extent in the IS field, but have generally been difficult to detect (Chin, Marcolin, & Newsted, 1996). Few studies have used analytic techniques that actually calculate the effect size; power levels tend to be low; and meta-analyses are theoretical (Ma & Liu, 2004; Mahmood, Hall, & Swanberg, 2001) or report inconsistent results (Cavaye, 1995). The inconsistent results in the meta-analyses are often blamed on different operationalizations of the constructs, uncontrolled research factors, inappropriate quantitative studies with little richness in the understanding of the influences, and poorly validated instruments (Cavaye, 1995).

The vast majority of previous studies on individual adoption and use of technology using TAM has not examined the potential dynamic influences of user differences. As a result, most studies in this domain implicitly suggest that demographic characteristics are less important than characteristics of the technology itself in determining whether specific technologies will be accepted or rejected by the intended user base. However, some emerging recent work has adopted a more people-centric position by testing the role of demographic characteristics. Particularly, Morris et al. (2005) and Venkatesh et al. (2003) have examined the moderating role of age and gender as key demographic characteristics on the TPB and TAM relationships respectively.

Building on this foundation, previous research has examined moderators that might be incorporated into theoretical models to provide key insights into how different individuals in organizations may think and make decisions differently when it comes to technology adoption and use. Previous studies called to pay attention to other potentially confounding demographic variables, such as, income, education, and occupation levels when studying sex-related differences in job attitudes and dispositional variables (Lefkowitz, 1994) or new technology adoption and use (Morris et al., 2005; Venkatesh et al., 2003).

Three Human Factors Differences in Individual Adoption and Use of Technology

Due to changes in the structure and diversity of the workforce, gender differences are becoming increasingly important in managing the development and implementation of new technology (Ahuja, 2002; Ong & Lai, 2004; Woodfield, 2002). In a developing nation, the demographics of the workforce may differ significantly from that of a developed nation. As an example of a developed nation, the ranks of older workers in the United States are increasingly female (Morris et al., 2005). Greater proportions of women are now employed into their 50s and 60s in America (Wellesley Centers for Women, 1999) than in previous decades, while the participation of similarly aged men in the workforce remains constant. These workforce demographics are in contrast to that of Saudi Arabia,

a less technologically advanced nation. Women constitute a much smaller percentage of the Saudi workforce, and the median age of a professional worker is much younger in Saudi Arabia than in the United States (Al-Gahtani, 2004). The social and cultural characteristics of Arab and Muslim societies differ from those of North America and Europe, and these characteristics are reflected in the overall demographics of the workforce.

To date there have been few in-depth studies to show the impact of gender on IT adoption in Saudi Arabian culture. In Saudi Arabia, as in some other Arab states, there is an acute separation of labor between men and women, and there exists a widely practiced segregation of the genders in many public roles. The growing number of women in the Saudi workforce, albeit slowly increasing, could potentially affect the adoption of IT in that country. Traditionally, women have not participated in the Saudi workforce (Esposito & Haddad, 1998). In the early 1990s, fewer than 10% of all employees in Saudi Arabia were women (Vassiliev, 1998), and this proportion hangs around 15% today (Kinninmont, 2006), reflecting small increases in participation each year. The prevailing Islamic culture within Saudi Arabia posits that women are not supposed to work outside of the home, except as directors of their own businesses, or as teachers, doctors, or nurses among women. Achieving gender integration in the Saudi workplace is made even more difficult in practice; as women are not allowed to work in public, save in unmixed women fields. In fact, the vast majority of Saudi workplaces employ a strict maintenance of separate working areas for men and women to conform to widely accepted religious and cultural practices (Al-Munajjed, 1997; Field, 1994).

In a study simultaneously conducted in three nations characterized by differing cultural beliefs and norms, Gefen and Straub (1997) demonstrated that gender roles represent an important social factor influencing perceptions and behaviors with respect to IT adoption. Their results indicate that gender does have an effect on the IT adoption process and provides a rationale to investigate whether gender moderates the effects of predictor variables in existing models of IT adoption and usage.

Like gender, age has also proven to be an important demographic variable of interest in organizational settings (e.g., Ford et al., 1996). This importance is derived from two societal trends: an increasingly younger workforce in developing nations and the rapid introduction of computer technology across virtually all job settings (Sharit & Czaja, 1994). In Saudi Arabia, for example, the population is a young population as 73% of the population is less than 30 years old and about 70% of the labor force is less than 40 years old (Ministry of Economy and Planning, 2002). As a result of these trends, organizations are finding themselves faced with a workforce with dramatically different demographic characteristics than in previous years. Consequently, understanding age differences is an important aspect of understanding how to effectively manage tomorrow's workforce (Venkatesh et al., 2003). With a workforce that is predominantly young and male, the effects of age and gender on the adoption and use of technology might have a different impact on Saudi organizations compared to those in the United States. The United States is a more technologically developed nation, with a workforce that is more balanced in gender, and older in age.

Education is also an important factor that influences organizational behavior, particularly with respect to the acceptance of new IT. Hill et al. (1998) found that technological changes are often brought into Arabic organizations by younger people who have been previously exposed to these technologies via scholarships in other more developed countries. The participants in the Hill study believed education to be the most important avenue to improve social standing in Arab society. Increasingly, more and more Saudis achieve higher levels of education (Vassiliev,

1998). In 1991, over 19% of female Saudi students leaving high school entered a university, as did 7.1% of male students. By 2004, 28% of Saudi students who were eligible, including 33% of the women and 22% of the men, participated in university-level education (UNESCO Institute for Statistics, 2004). The rapid increase in the number of students who complete programs of higher education has led to a better educated and to a more technologically savvy workforce. Thus, a better educated workforce could promote the adoption of new IT in the workplace.

Until recently, Saudi women's education concentrated on the humanities and social service. By reviewing the Saudi pre-college curriculum it can be noticed that no computer courses are offered to girls compared to boys who are offered three courses over three years in the high school program. The role of girls' education in economic development, therefore, required a careful, well-planned policy in order to develop balanced professional educational programs for women that would satisfy the growing economic demands of the nation yet, at the same time, maintain social and religious norms (Al-Wakeel, 2001).

Understanding how social and cultural factors, such as gender, age, and level of education can influence the adoption of IT, is useful in promoting organizational diffusion of IT in non-Western cultures. Many studies show how gender, age, and level of education affect IT adoption and usage, although most were conducted within developed nations (Ahuja, 2002; Ford et al., 1996; Woodfield, 2002). The present work advances individual acceptance research by integrating some theoretical perspectives common in the literature and incorporating three moderators to account for dynamic influences of human characteristics in a technological context. This study attempts to extend TAM to explore three interacting (moderating) human factors in a developing country that should enhance our understanding of instrumental influencing factors in the context of technology adoption and use decisions. Hopefully, this study would enable some comparisons with technologically advanced countries for multinational and trans-cultural joint ventures.

HYPOTHESES

As TAM keeps being popular and parsimonious across a wide spectrum of technologies and users, it was chosen as the model of this study to achieve two main goals: (1) to test for the applicability of TAM in the Saudi Arabian setting, and (2) to extend TAM with two core determinants of attitude and intention and three moderators as in Figure 1.

Firstly, to the best of our knowledge, this study appeared to be the first attempt to test for the applicability of TAM in the Saudi Arabian setting. Previous research suggests that the TAM model may not hold equally well across cultures (Straub et al. 1997, p. 9). Lacking an a priori rationale for why TAM would not apply to Saudi Arabia, we posit that TAM will predict acceptance and use of computers in the Saudi Arabian setting. Thus one main question posited by this study was "would TAM apply to the Saudi Arabian culture?" The following hypotheses can be asserted to be true in the setting of Saudi Arabia as a developing country in the Middle East:

H1: *The original TAM structure (without moderating/interacting factors) will hold well in the setting of Saudi Arabia.*

Six sub-hypotheses were derived from H1 which are stated in the following:

H1a: *Behavioral intention will have a positive direct effect on computer use.*

H1b: *Attitude toward using will have a positive direct effect on behavioral intention.*

H1c: *Perceived usefulness will have a positive direct effect on attitude toward using.*

H1d: *Perceived usefulness will have a positive direct effect on behavioral intention.*

H1e: *Perceived ease of use will have a positive direct effect on attitude toward using.*

H1f: *Perceived ease of use will have a positive direct effect on perceived usefulness.*

Secondly, this study attempts to extend TAM by incorporating three moderating human factors (age, gender, and educational level). The TAM core relationships are expected to be moderated by these human factors in the setting of Saudi Arabia as a developing country in the Middle East. Three core relationships are of most interest to researchers in the adoption and use of new technologies: PUSEF-A, PUSEF-BI, and PEOU-A. We need to understand how these three relationships are moderated by some human factors in order to promote positive effects and mitigate negative effects toward computer technology adoption and use.

Previous research (Morris et al., 2005; Venkatesh & Morris, 2000; Venkatesh et al., 2003) has demonstrated that these three TAM relationships are moderated either by gender or age or both with varying moderation patterns among the TAM constructs. Next, the two primary constructs of TAM (PUSEF and PEOU) and these three core relationships are discussed subsequently toward the development of the rest of the hypotheses.

Perceived Usefulness

PUSEF is defined as the degree to which a person believes that using a particular system would enhance his or her job performance. TAM previous research has consistently shown PUSEF to be the key driver of attitude and intention (Davis et al., 1989; Mathieson, 1991; Taylor & Todd, 1995; Venkatesh & Davis, 2000). PUSEF captures the same concept of relative advantage (Moore & Benbasat, 1991) or performance expectancy (Venkatesh et al., 2003) suggesting a substantial similarity among the construct definitions, measurement scales, and relationships.

Gender was not included in the original TAM; however, gender is theorized to play a moderating role. Empirical evidence demonstrated that PUSEF was more salient for men while PEOU was more salient for women (Venkatesh & Morris, 2000). Previous studies on gender differences in the determinants of intention and behavior (Venkatesh, Morris, & Ackerman, 2000) found that men were influenced by instrumentality more than women who were more strongly influenced by social factors and environmental constraints than men.

Similar to gender, age was not included in the original TAM, but also theorized to play a moderating role. Research on job-related attitudes suggests that younger workers may place more importance on extrinsic rewards (i.e., performance measures). With respect to gender-based attitudes about technology's role in the workplace, research on age and job-related attitudes has demonstrated that job needs and preferences will, in fact, change with age. Drawing upon other research, Morris et al. (2005) suggest that instrumental factors related to technology's usefulness and its influence on job productivity will be more important to older men than older women, thus resulting in a greater influence for usefulness in predicting new technology adoption among older men than older women.

Gender and age differences have been shown to exist in technology adoption contexts also (Morris & Venkatesh, 2000; Venkatesh & Morris, 2000; Zhang, 2004). In looking at gender and age effects, it is interesting to note that Levy (1988) suggests that studies of gender differences can be misleading without reference to age. Levy elaborated that for example, given traditional societal gender roles, the importance of job-related factors may

change significantly for working women between the time that they enter the labor force and the time they reach childrearing years.

In a recent study on gender and age differences in employee decisions about new technology, Morris et al. (2005) drew a TPB-TAM parallelism and suggest that the PUSEF-BI relationship is moderated by gender and age and the pattern was nearly identical to that observed on the attitude-intention relationship in TPB. They argue that instrumental factors related to technology's usefulness and its influence on job productivity are more important to older men than older women, thus resulting in a greater influence for PUSEF in predicting new technology adoption among older men than older women. Furthermore, they suggested that with the ever-expanding presence of women in the professional workforce, traditional gender roles may be in a state of flux and, therefore, anticipating few if any differences among younger men and women in the influence of PUSEF of the technology on technology adoption.

However, there is inconsistent evidence about the relationship of age and innovativeness (Rogers, 1995). Generally speaking, younger individuals are known to be pioneering in technology adoption and have a higher tendency toward change compared to older individuals. Old workers are anticipated to be laggard with regard to their motive toward computers than their younger counterparts. Conversely, younger workers are expected to be more ready to develop a strong intention to adopt computers immediately when they perceive computers to be useful in their work. Old workers possibly need first to develop a favorable attitude toward computers that lead to develop their intention to adopt computers.

Consequently, there is reason to expect that the relationships between PUSEF and both of attitude and intention will be moderated by gender and age in the Saudi settings such that the following hypotheses can be derived as follows.

H2: *The influence of perceived usefulness (PUSEF) on attitude toward using computers (A) will be moderated by* ***gender****, such that the effect will be stronger for men.*

H3: *The influence of perceived usefulness (PUSEF) on attitude toward using computers (A) will be moderated by* ***age****, such that the effect will be stronger for older workers.*

H4: *The influence of perceived usefulness (PUSEF) on behavioral intention (BI) will be moderated by* ***gender****, such that the effect will be stronger for men.*

H5: *The influence of perceived usefulness (PUSEF) on behavioral intention (BI) will be moderated by* ***age****, such that the effect will be stronger for younger workers.*

Perceived Ease of Use

PEOU is defined as the degree of ease associated with the use of the system. PEOU capture the same concept of complexity (Moore & Benbasat, 1991) or effort expectancy (Venkatesh et al., 2003) suggesting a substantial similarity among the construct definitions and measurement scales (Venkatesh et al., 2003). As stated earlier, gender was not included in the original TAM, which is theorized to play a moderating role and could be more pertinent to PEOU. However, gender is an important construct that has received little attention in the context of TAM research (Gefen & Straub, 1997). Venkatesh and Morris (2000), drawing upon other research, suggest that PEOU is more salient for women than for men. Like gender, age has also proven to be an important demographic variable of interest in organizational settings—although not included in the original TAM.

Previous research has shown that situational constraints are more important determinants of

technology adoption and use for women than they are for men (Venkatesh et al., 2000). Recent research further suggests that the effect of situational constraints may be differentially experienced by older workers due to age-related changes in cognitive, sensory, and physiological abilities. For example, there is a substantial evidence to indicate that behaviors that comprise cognition and the ability to process complex stimuli decline with age. Accordingly, older individuals may believe that the relative benefits that might accrue to learning something new (e.g., new technology) may not be worth the incremental effort required. Thus, for older individuals, one would expect that perceptions of ease of use would be particularly important in their decision to use (or not use) new technology.

Increased age has been shown to be associated with difficulty in processing complex stimuli and allocating attention to information on the job (Plude & Hoyer, 1985), both of which may be necessary when using computer systems. Prior research supports the notion that constructs related to PEOU will be stronger determinants of individuals' attitude and intention for women (Venkatesh & Morris 2000; Venkatesh et al., 2000) and for older workers (Morris & Venkatesh, 2000).

The recent TPB-TAM parallelism study on gender and age differences in employee decisions about new technology suggests that the PEOU-BI relationship is moderated by gender and age and the pattern was nearly identical to that observed for the perceived behavioral control (PBC)-BI relationship in TPB. Perceived behavioral control is defined as the "… perceived ease or difficulty of performing the behavior" (Ajzen, 1991, p. 188) which is some how similar to PEOU. The ties of PBC to PEOU in TAM are strong and have been previously documented. Thus, we expect that the effect of PEOU on attitude will be moderated by gender and age similar to the moderation of the PBC-BI relationship in TPB.

Morris and Venkatesh (2000) argue that, for older individuals, the degree to which the new technology is perceived to be easy to use, for example, requiring little or no formal training, will be more important in their decision to adopt or reject that technology than it will be for younger workers. They also suggest that access to resources and assistance provided by particular user interface design features designed to alleviate the cognitive load associated with complex stimuli are particularly important to older workers. Given these differences in cognitive processing, we believe that previously reported age differences in the importance of PEOU will be particularly evident with increasing age and will be less pronounced for younger workers.

Educational level was investigated in prior research as a potential confounding factor among other demographic variables including income and occupational level. Lefkowitz (1994) suggests that not controlling for the effects of such covariates "underestimate the complexity of the issue under study and, at worst, are misleading" (p. 341). The Saudi curriculum only offers an introductory computer course in some programs at the college level but until recently it was introduced in the boys' high school program, so we expect that the effect of computer complexity will be stronger for individuals at higher educational levels. Therefore, in the current research, beyond examining gender and age differences, we examined the potential moderating effect of educational level. According to our survey sample, educational level is classified such that those who graduated college or have some post graduate studies are classified as *high*; however, those with some or no college education or some vocational/ technical school are classified as *low*.

Drawing from the arguments made in the context of PEOU, we expect gender, age, and educational level to work in an assortment (see Levy, 1988). Thus, we propose that PEOU will be most salient for *women*, particularly those who are *older* and with relatively *lower* educational level.

H6: *The influence of perceived ease of use (PEOU) on attitude toward using computers (A) will be moderated by* ***gender*** *such that the effect will be stronger for women.*

H7: *The influence of perceived ease of use (PEOU) on attitude toward using computers (A) will be moderated by* ***age*** *such that the effect will be stronger for older workers.*

H8: *The influence of perceived ease of use (PEOU) on attitude toward using computers (A) will be moderated by* ***educational level*** *such that the effect will be stronger for workers of higher educational levels.*

In summary the model proposed here (Figure 1) extends TAM by including gender, age, and educational level as moderators of key relationships. Specifically, the hypotheses predict that the effects of PUSEF and PEOU on attitude and intention will each be moderated by gender and age, while it is hypothesized that the effect of PEOU on attitude will be moderated by the individual educational level. The proposed relationships are summarized in Table 1.

METHOD

Sample and Procedure

Participants in this study were end users from 56 private and public organizations in Saudi Arabia. The participating organizations are distributed throughout the country and represented various types of institutions: banking, merchandising, manufacturing, petroleum industries, educational, health, and public services.

This sample included essentially any hands-on use of computers for the purpose of their work. Basically, this study is a part of a financed project by the Saudi government to build a model of antecedents, mediating, and outcome factors affecting the adoption and acceptance of computers in Saudi Arabia. A list of governmental ministries with their branches and major companies in the main four provinces in the country was collected with the help of the chamber of commerce in each region. A letter signed by the vice president of the university where the researcher is affiliated to, was sent to 136 private and public organizations across the country seeking their participation in the study. Those organizations that accepted to participate were asked to nominate a contact person to liaise with the researcher in distributing and collecting the survey questionnaires. From the 1,900 end users surveyed, 1,190 were usable

Table 1. Summary of proposed relationships: Gender, age, and educational level differences

Perceptions of …	Predicted Construct	More Important to …
Perceived usefulness of technology	A	Older, men
Perceived usefulness of technology	BI	Younger, men
Perceived ease of use of technology	A	Older, women, higher educational levels

A = Attitude toward using technology

BI = Behavioral intention to use technology

responses, thus achieving a response rate of about 62% through that procedure.

Recalling that system usage should be voluntary in order to be pertinent (Adams et al., 1992; DeLone & McLean, 1992), the sample would need to be pruned leaving out those who strictly declare that their use of computers was mandatory. This trimming down reduced the sample to 722 respondents of voluntary usage. Next, this net sample was used for the partial least squares (PLS) analysis to test the measurement model (scales composite or internal consistency reliabilities and constructs discriminant validity) and the structural model.

Measurement

The Appendix presents the various scales used to measure the constructs of TAM including the interacting/moderating demographic variables. Following Morris et al. (2005) and Venkatesh et al. (2003), gender was recoded as Female=0 and Male=1.

ANALYSIS

A PLS latent variable modeling approach for measuring interaction effects (Chin et al., 1996) is used here. This approach uses product indicators in a PLS analysis to model interaction effects which is quite new and effective method. PLS can be a powerful method of analysis because of the minimal demands on measurement scales, sample size, and residual distributions. Although PLS can be used for theory confirmation, it can also be used to suggest where relationships might or might not exist and to suggest propositions for later testing. As an alternative to the more widely known covariance fitting approach, the component-based PLS avoids two serious problems: inadmissible solutions and factor indeterminacy (Fornell & Bookstein, 1982). The PLS procedure has been gaining interest and use among IS researchers in recent years (Aubert, Rivard, & Patry, 1994; Chin & Gopal, 1995; Compeau & Higgins, 1995) because of its ability to model latent constructs under conditions of non-normality and small to medium sample sizes. Being a components-based structural equations modeling technique, PLS is similar to regression, but simultaneously models the structural paths (i.e., theoretical relationships among latent variables) and measurement paths (i.e., relationships between a latent variable and its indicators). Rather than assume equal weights for all indicators of a scale, the PLS algorithm allows each indicator to vary in how much it contributes to the composite score of the latent variable. Thus indicators with weaker relationships to related indicators and the latent construct are given lower weightings. In this sense, PLS is preferable to techniques such as regression which assume error free measurement (Lohmöller, 1989; Wold, 1989).

RESULTS

The profile of the participants is presented in Table 2. The research model depicted in Figure 1 was analyzed using PLS-Graph (build 1126), a PLS structural equation modeling (SEM) tool. PLS-Graph simultaneously assesses psychometric properties of the measurement model (i.e., the reliability and validity of the scales used to measure each variable) while estimating the parameters of the structural model (i.e., the strength of the path relationships among the model variables). Furthermore, PLS-Graph build 1126 enables the simultaneous analysis of up to 200 indicator variables, thus enabling the analyses of extensive, multiplicative interactions among latent and moderator variable indicators.

The Measurement Model

Reliability results from testing the measurement model are reported in Table 3. The data indicates

Table 2. Profile of the participants (N=722)

Demographic Variable	Statistics
Gender	Male: 589 (81.6%)
	Female: 133 (18.4 %)
Age	Mean = 38.2 Years, Range 18-58 Years
18-30	256(35.5%)
31-40	310(42.9%)
41-50	136(18.8%)
51 or more	20(2.8%)
Education levels	
Less than high school	37(5.1%)
High school	115(15.9%)
Some college	155(21.5 %)
College graduates	347(48.1%)
Post graduates	68(9.4%)

Table 3. Assessment of the measurement model

Variable Constructs	**The Composite Reliability (Internal Consistency Reliability)**	**Average Variance Extracted/Explained**
Perceived ease of use	.90	.700
Perceived usefulness	.90	.691
Attitude toward computers	.95	.793
Behavioral intention	.76	.513
Use behavior	.85	.584

that the measures are robust in terms of internal consistency reliability as indexed by the composite reliability. The composite reliabilities of the different measures in the model range from .76 to .95, which exceed the recommended threshold value of 0.70 (Tabachinck & Fidell, 1983). In addition, the average variance extracted (AVE) for each measure exceeds 0.50 (Fornell & Larcker, 1981). Table 4 reports the results of testing the discriminant validity of the measure scales. The bolded elements in the matrix diagonals represent the square roots of the AVEs, and are greater in all cases than the off-diagonal elements in their corresponding row and column, confirming the discriminant validity of the scales.

We tested convergent validity by extracting the factor loadings (and cross loadings) of all indicator items to their respective latent constructs. Presented in Table 5, these results indicate that all items loaded: (1) on their respective construct (i.e., the bolded factor loadings) in all cases greater or equal to 0.7 (from a lower bound of 0.70 to an upper bound of 0.90); and (2) more highly on their respective construct than on any other construct. Satisfying these two particular metrics comprises a common rule of thumb to indicate convergent

Table 4. Discriminant validity (intercorrelations) of variable constructs

Latent Variables	1	2	3	4	5
1. Perceived ease of use	**.84**				
2. Perceived usefulness	.43	**.83**			
3. Attitude toward computers	.36	.41	**.89**		
4. Behavioral intention	.49	.41	.42	**.72**	
5. Use behavior	.30	.20	.32	.50	**.76**

*Table 5. Factor loadings (**bolded**) and cross loadings*

	Perceived Ease of Use	Perceived Usefulness	Attitude Toward Computers	Behavioral Intention	Use Behavior
PEOU1	**0.83**	0.34	0.30	0.41	0.18
PEOU2	**0.82**	0.39	0.33	0.46	0.34
PEOU3	**0.83**	0.33	0.26	0.38	0.25
PEOU4	**0.86**	0.37	0.29	0.37	0.21
PUSEF1	0.37	**0.79**	0.33	0.29	0.13
PUSEF2	0.32	**0.87**	0.32	0.34	0.15
PUSEF3	0.37	**0.88**	0.34	0.37	0.17
PUSEF4	0.36	**0.78**	0.38	0.36	0.20
ATT1	0.33	0.38	**0.90**	0.40	0.29
ATT2	0.36	0.38	**0.90**	0.38	0.29
ATT3	0.35	0.37	**0.90**	0.41	0.29
ATT4	0.29	0.37	**0.88**	0.34	0.28
ATT5	0.25	0.34	**0.87**	0.30	0.27
BI1	0.46	0.45	0.26	**0.70**	0.22
BI2	0.34	0.32	0.28	**0.71**	0.23
BI3	0.28	0.17	0.34	**0.78**	0.55
USE1	0.23	0.13	0.24	0.43	**0.81**
USE2	0.22	0.14	0.25	0.37	**0.77**
USE3	0.26	0.15	0.24	0.39	**0.78**
USE4	0.20	0.19	0.25	0.34	**0.70**

validity (Yoo & Alavi, 2001). Furthermore, each item's factor loading on its respective construct was highly significant ($p < 0.01$). These loadings indicate the convergent validity of the measures used for the latent constructs.

The Structural Model

Table 6 presents the structural model results. Results in parentheses ( ) for the model when *omitting the influence of the interacting moderator variables* (i.e., the original TAM model only). All original TAM relationships (depicted in Figure 1) are all significant and have strong effects. Thus

Table 6. PLS results of the extended TAM model

Predicted Constructs / Predictors / Moderators	Predicted (Latent) Constructs		
	Attitude (A)	Behavioral Intention (BI)	Usage
# Predicting variables	2	2	1
# Moderator (interacting) variables	4	1	–
Variance explained (R^2)	0.259 (0.211)	0.253 (0.242)	0.249 (0.250)
Direct predictors	**Path Coefficients**		
Perceived ease of use (PEOU)	0.38 (0.22)	–	–
Perceived usefulness (PUSEF)	0.11* (0.32)	0.34 (0.29)	–
Attitude towards computers (A)	–	0.31 (0.30)	–
Behavioral intention (BI)	–	–	0.50 (0.50)
Moderators			
Age X PUSEF	0.456	-0.126	–
Age X PEOU	-0.375	–	–
Gender X PEOU	-0.100	–	–
Education X PEOU	0.202	–	–

Results in ( ) are for the original TAM when omitting the influence of the moderators.

All path coefficients are significant at $p < 0.05$ or better.

** PUSEF → A (beta = 0.11 is n.s.) when including the influence of the moderators.*

we can say that the whole structure of TAM appears to hold very well for the Saudi setting. It is important to note that the strength and direction (i.e., positive or negative) of the direct, TAM main path coefficients cannot be adequately interpreted unless the influences of corresponding interacting variables are simultaneously considered. The results of the complete structural model, including the influence of the interacting variables, are also presented in Table 6. All beta path coefficients in ( ) are positive (i.e., in the expected direction) and statistically significant. In particular, note the positive and significant impact of PUSEF on A (beta = 0.32, $p < 0.05$) (which is rendered non-significant [beta = 0.11, $p > 0.05$] in conjunction with the interaction of age as depicted in Figure 1). However, the (original TAM) model only explains only 24.2% of the variance in behavioral intention and 25% of the variance in usage. In contrast, the results which include the effects of the interacting variables, explain a significantly larger proportion of the respective variance in BI ($R^2 = .253$) but a bit smaller in USE ($R^2 = .249$). This is the purpose of user acceptance models: to explain as much of intention to use, and usage behavior, as possible. Thus, the inclusion of the interacting moderator variables has inherent value in that they serve to more fully explain usage behavior. However, in the presence of multiple interactions among the variables, it becomes more problematic to explain the effects of each individual, direct variable on the predicted constructs.

Let us look closely at the results of the complete structural model presented Table 6. The beta values of the path coefficients, indicating the direct influences of the predictor upon the predicted latent constructs, are presented. PEOU exhibited a strong positive direct influence (beta = 0.38, $p < 0.001$) on A. PUSEF exhibited a *positive* (beta = 0.11, not significant at $p < 0.05$) direct influence on A and PUSEF exhibited a strong positive direct influence (beta = 0.34, $p < 0.001$) on BI, and A exhibited a strong positive influence on BI (beta = 0.31, $p < 0.001$). Finally BI had a strong positive (beta = 0.50, $p < 0.001$) direct influence on USE. Of course, the influence of BI on USE also reflects the indirect influences of PUSEF, PEOU, and A on USE as mediated through BI.

For the moderator (interacting) variables, statistically significant beta path coefficients are indicated. Statistically non-significant (at $p > 0.05$) moderating paths in the research model (Figure 1) are omitted from the results in Table 6 but presented in dotted lines in Figure 1. Age had a strong positive (beta = 0.456, $p < 0.01$) interacting effect with PUSEF upon A and also exhibited a negative (beta = -0.126, $p < 0.05$) interacting effect with PUSEF upon BI. Age also exhibited a negative (beta = -0.375, $p < 0.01$) interacting effect with PEOU upon A. Educational level had a strong positive (beta = 0.202, $p < 0.01$) interacting effect with PEOU upon A. Gender only exhibited a significant interacting effect with PEOU but negative (beta = -0.100, $p < 0.05$).

The direct influences of PUSEF and PEOU combined with the moderating influences of age x PUSEF, age x PEOU, gender x PEOU and educational level x PEOU account for approximately 26% of the variance in A ($R^2 = .259$). The direct influences of PUSEF and A combined with the moderating influences of Age x PUSEF account for 25.3% of the variance in BI ($R^2 = .253$). The direct influence of BI on USE (which mediates the indirect influences of PUSEF and A on USE through BI) account for approximately 25% of the variance in USE ($R^2 = .249$).

The effect size f^2 (Cohen & Cohen, 1983) resulting from adding the interaction paths on each outcome construct in the model is calculated as per the following equation:

The effect size $f^2 = [R^2$ *(interaction model)* $- R^2$ *(main effects)]* $/ R^2$ *(interaction model).*

The effect sizes f^2 for the three outcome constructs (A, BI and Usage) in the TAM model were 0.185, 0.043 and -0.004 respectively. A small, medium, or large effect is indicated by f^2 values of .02, .15, or .35, respectively (Gefen et al., 2000). The f^2 resulting from adding the interaction paths on *Usage* in this case was .004—a value which does not reach the recommended f^2 value for a small effect. The f^2 for *behavioral intention* (.043) was about twofold the value recommended for a small effect. Finally, the f^2 for *attitude toward using* computers (.185) exceeded the value recommended for a medium effect.

DISCUSSION AND IMPLICATIONS

The primary objectives of this study were (1) to investigate the applicability of TAM in the Arab culture and (2) to extend TAM with three human moderating/interacting factors. The results of this survey validate the predictive constructs as determinants of predicted constructs in the technology acceptance model in Saudi Arabia. All core relationships among TAM constructs as per the structure of TAM (Figure 1) are validated in this survey. Thus toward the first objective, this study is successful as the structure of TAM holds well in the Saudi settings, and TAM proved to effectively predict computer technology adoption and use in the Saudi culture. Thus hypotheses H1a-H1f are fully supported in the current study.

This study supports the findings of Rose and Straub (1998) in testing for the applicability of TAM in the Arab culture for broad theory testing and serves the development of international busi-

ness via better global information management. Straub et al. (2001) focus on the transfer of IT to the Arab world and call for theory testing and for technology policy setting as they have strong implications for transnational firms and managers charged with introducing IT in foreign ports, subsidiaries, offices, and plants. Niederman et al. (2002) contend that testing TAM in a multinational setting is serving global information management which in turn contributes to the development of international business. Taken together, practitioners may implement approaches that are suitable for introducing IT in technologically advanced cultures to certain extents in less developed cultures. When introducing new IT applications, management could focus on rational factors like PUSEF and PEOU to achieve higher acceptance rate and better implementation. With reference to prior research, both factors proved to be major determinants of IT acceptance in developed and developing countries (e.g., Elbeltagi, McBride, & Hardaker, 2005).

Secondly, this study explores three interacting/moderating factors that operate through core relationships between these two rational factors and attitude and behavioral intentions to adopt and use computers. This research and other prior research (e.g., Morris et al., 2005; Venkatesh et al., 2003) suggest that instrumentality (usefulness) is a key determinant of attitude toward using technology, while usefulness and attitude are key determinants of BI in technology adoption contexts. However, this study indicates that the influence of usefulness on attitude diminishes when including the influence of the interacting variables as PEOU strongly and solely influences attitude toward using technology. There is no significant influence of gender as an interacting variable on the PUSEF-A and PUSEF-BI relationships in the current study. Apart from type of sex, Saudi knowledge workers perceive computers to be useful. In essence, compared to Saudi men, Saudi women are considered laggard in IT adoption and use due to cultural and opportunistic conditions in favor of men. We speculate that gender might have significant moderating effects on the influence of PUSEF on technology adoption among Saudi men and women. However, surprisingly, our findings did not support this notion as both gender interaction effects on the PUSEF-A and PUSEF-BI relationships are not significant. Gender interaction effects decline to be significant among the groups of workers on the PUSEF-A and PUSEF-BI relationships in the current study and a more unisex pattern of results emerges here despite feasible hypothesized differences. With more presence of women in the professional workforce (given the policy of Saudization) and increasing educational attainments of Saudi women, besides higher qualifications of women, participants in this study could be viable reasons for closing this gap. Hence, H2 and H4 are not supported in the current research.

Regarding the influence of age as a moderator on the PUSEF-A and PUSEF-BI relationships, age proved to significantly influence both relationships in the current study. Moreover, the moderation effect of age appeared according to the hypothesized groups of age in both cases. Age significantly moderates the PUSEF-A relationship such that the effect is stronger for older Saudi workers. As expected, our findings corroborate that instrumental factors related to technology's usefulness and its influence on job productivity are more important to older individuals, thus resulting in a greater influence for usefulness in predicting attitude toward new technology adoption among older workers. This finding is consistent with Morris et al. (2005). With regard to the influence of age as a moderator on the PUSEF-BI relationship, age significantly moderate the PUSEF-BI relationship such that the effect is stronger for younger Saudi workers.

Gender moderation on the PUSEF-A relationship is not significant, as stated earlier, thus older Saudi workers, both men and women, perceive instrumentality to be important in promoting favorable attitude toward computers. Maybe it is

worth noting that the proportional representation of elderly females in this study is 27.8% among the Saudi women sample. Consistent with Venkatesh et al. (2003), our findings show that age exhibits a significant negative interacting effect with PUSEF upon BI indicating that the effect of PUSEF on BI is greater for younger workers. This indicates that the degree to which an individual believes that using computers will help him or her to attain gains in job performance is instrumental in promoting behavioral intentions to use computers for younger workers rather than for older workers in the Saudi culture apart from type of sex. Younger workers are ready to develop a strong intention to adopt computers immediately when they perceive computers to be useful in their work whereas, according to TAM, older workers need first to develop a favorable attitude toward computers that lead to develop their intention to adopt computers. Thus, both H3 and H5 are fully supported in the current research.

With regard to PEOU, all three moderators were found to have significant effects on the PEOU-A relationship. Age exhibited a strong and significant negative interacting effect with PEOU on A. This indicates that the influence of PEOU on attitude toward using computers is significantly moderated by age and the effect is stronger for younger workers. Specifically, with increasing age, the negative impact of PEOU on A is diminished and rendered positive with older workers. Our finding here contradicts H7, and thus not supported here, as the influence of PEOU on A is moderated by age and the effect is more important to younger workers than to older workers. This discrepancy might be due to variation of computer usage by these age groups. Younger users may attempt some novel and therefore relatively difficult computer applications while older users maybe occupied with routine applications. This would let younger workers perceive computers as rather challenging and more complex, contrary to older workers.

Gender significantly moderates the influence of PEOU on A. Specifically, as gender changes from female (dummy variable 0) to male (dummy variable 1), the negative impact of PEOU on attitude toward using computers is diminished, as evidenced by the negative beta coefficient value of -0.100 ($p < 0.05$) in the interaction of PEOU x Gender on A. Stated more simply, these results provide evidence that "the degree to which an individual believes that computers are easy to use in the workplace" is instrumental in promoting favorable attitudes toward using computers for women than for men in the Saudi culture. Not surprisingly, Saudi females suffer from computer complexity perceptions as about 30% of the girls in our sample, with high school, entered the workforce without having a single computer course during their school years compared to boys who are offered three courses. In summary, our findings indicate that Saudi females regard "the degree of ease associated with the use of computers," to be more important in promoting favorable attitudes toward using computers than do Saudi males. Hence, H6 is fully supported. Our findings should alert managers and practitioners to set up the appropriate training programs in order to overcome such unfavorable attitudes toward computers due to Saudi female perceptions of certain degrees of complexity related to computer acceptance and adoption.

Finally, educational level significantly and positively moderates the influence of PEOU on A. This interacting relationship indicates that workers with higher educational levels regard "the degree of ease associated with the use of computers," to be more important in promoting favorable attitude toward computers than do workers with lower educational levels in the Saudi culture. Thus H8 is fully supported.

A decade ago, a new trend cast the Saudi labor market as demanding for a one or two year computer diploma and some proficiency in English. Saudi nationals with some college or high school

certificates were given this opportunity to attain a satisfactory post in the private or public sector. Higher educational levels with no systematic computer education or training, who are considered overqualified for this career, lack such opportunity and therefore are expected to suffer from computer complexity. If one responsibility of higher education is to replace foreign workers with qualified Saudi men and women (Center for International Higher Education, 2000), then the education system should focus on IT skills needed in the private sector, since this is where many new jobs will be created (Baki, 2004).

Taking together the three interacting/moderating factors operating on PEOU-A, this study provides evidence that the influence of PEOU on attitude toward using computers is significantly moderated by these three interacting/moderating factors. The influence of these moderators on PEOU-A are manifested such that the effect is more important to women, younger workers, and workers of higher educational levels.

CONCLUSION

The present study adds more confidence and support to previous studies about the applicability of TAM in the Arab countries and more specifically in the Saudi culture. This should enable practitioners to exploit TAM to unveil users' early perceptions about the system under implementation. Practitioners can embark on a parsimonious tool that is applicable across a wide spectrum of technologies and users for acquiring early predictive and preventive measures to ensure higher rate of acceptance while saving time and reducing costs to a great extent.

This study also extends TAM by incorporating gender, age, and educational level as moderators of the model's core relationships. In so doing, the present work helps managers to understand the details of the impact of these moderators on decisions made by individuals about new technology adoption and use in the workplace. It is important to emphasize that most of the key relationships in the model are moderated. For example, age has received very little attention in the technology acceptance research literature, yet our results indicate that it moderates all of the key relationships in TAM in Saudi Arabia. The influence of PUSEF on attitude toward using computers is moderated by age and the effect is found to be stronger for older workers whereas the influence of PUSEF on BI is moderated by age and the effect is stronger for younger workers. The influence of PEOU on A toward using computers is moderated by age and the effect proved to be stronger for younger workers.

Surprisingly, gender did not significantly moderate the PUSEF relationships with A and BI indicating that a unisex pattern emerges here. The effect of perceiving computer usefulness on their decision to adopt is quite similar to men and women among Saudi workers. However, gender significantly moderated the influence of PEOU on A toward using computers and the effect is stronger for women. Finally, the influence of PEOU on A toward using computers is moderated by educational level and the effect is stronger for workers with higher educational level.

Besides being popular and parsimonious across a wide spectrum of technologies and users, the TAM model provides diagnostic measures that could help practitioners identify and evaluate strategies for enhancing user acceptance. Previous research contends that TAM lends a promising practical tool for early user acceptance testing and can be applied to understand the behavior of both experienced and inexperienced users. TAM also permits the ability to research the effects of external factors to TAM. In addition to our findings, previous TAM research findings supplemented with the new trend of researching interacting/moderating factors (e.g., Morris et al., 2005; Venkatish et al., 2003), constitute a rich reference to endorse TAM. 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 higher rate of user acceptance.

More importantly, with the ever-expanding of business globalization, multinational and transcultural enterprises should have better understanding about the influential factors in the work context of computer use by Arab end users. The findings of this study are hopefully helpful to globalized businesses in taking the appropriate measures for their IT adoption and use in their subsidiaries located in the Arab world. Our findings can lend globalized businesses better insight on how to deal with this part of the world to foster successful IT implementation, adoption and use.

ACKNOWLEDGMENT

The author wishes to thank the associate editor and five anonymous reviewers for their invaluable comments and suggestions on earlier versions of this article. Extended thanks go to King Abdul-Aziz City for Science and Technology (KACST)—Saudi Arabia for providing financial support for this research project and to the administration of KKU for their help throughout the project phases.

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ENDNOTE

[1] According to http://www.scholar.google.com as of September 10, 2007

APPENDIX: SURVEY INSTRUMENT

Subjects responded to the following five (attitude toward using) questions by marking "X" in the center of one of the seven places indicated for each question:

Attitude

(ATT1) All things considered, my using computers is:

bad								good
	extremely	quite	to a certain extent	neutral	to a certain extent	quite	extremely	

(ATT2) All things considered, my using computers is:

foolish								wise
	extremely	quite	to a certain extent	neutral	to a certain extent	quite	extremely	

(ATT3) All things considered, my using computers is:

unfavorable								favorable
	extremely	quite	to a certain extent	neutral	to a certain extent	quite	extremely	

(ATT4) All things considered, my using computers is:

harmful								beneficial
	extremely	quite	to a certain extent	neutral	to a certain extent	quite	extremely	

(ATT5) All things considered, my using computers is:

negative								positive
	extremely	quite	to a certain extent	neutral	to a certain extent	quite	extremely	

Please indicate your level of agreement with the following statements, where 1 is extremely disagree and 7 is extremely agree.

Perceived Ease of Use

(PEOU1) My interactions with computers are clear and understandable.
(PEOU2) It is easy for me to become skillful using computers.
(PEOU3) I find computers easy to use.
(PEOU4) Learning to use computers is easy for me.

Perceived Usefulness

(PUSEF1) I find computers useful in my job.
(PUSEF2) Using computers in my job enables me to accomplish tasks more quickly.
(PUSEF3) Using computers in my job increases my productivity.
(PUSEF4) Using computers enhances my effectiveness on the job.

Behavioral Intention

(BI1) To do my work, I would use computers rather than any other means available.
(BI2) I predict I will use computers on a regular basis in the future.
(BI3) What are the chances in 100 that you will continue as a computer user in the future? (Choose one.)

☐	Zero	☐	51 – 70%
☐	1 – 10%	☐	71 – 90%
☐	11 – 30%	☐	More than 90%
☐	31 – 50%		

Usage

(USE1) On an average working day, how much time do you spend using computers? (Choose one.)

☐	Almost never	☐	1 – 2 hours
☐	Less than ½ hour	☐	2 – 3 hours
☐	From ½ - 1 hour	☐	More than 3 hours

(USE2) On average, how frequently do you use computers? (Choose one.)

☐	Less than once a month	☐	A few times a week
☐	Once a month	☐	About once a day
☐	A few times a month	☐	Several times a day

(USE3) How many different computer applications have you worked with or used in your job? (Choose one.)

☐	One	☐	6 – 10 applications
☐	Two	☐	More than 10 applications
☐	3 – 5 applications		

(USE4) According to your job requirements, please indicate each task you use computers to perform (Choose as many as applicable):

☐	Letters and memos	☐	Analyzing problems and alternatives
☐	Producing reports	☐	Budgeting
☐	Data storage and retrieval	☐	Controlling and guiding activities
☐	Making decisions	☐	Electronic communications with others
☐	Analyzing trends	☐	Others (please indicate . . . . . .)
☐	Planning and forecasting	☐	Others (please indicate . . . . . .)

Demographic (Moderator) Variables
Age: (Choose one.)

☐	Less than 20 years	☐	41-50 years
☐	20-30 years	☐	over 50 years
☐	31-40 years		

Gender: (Choose one.)

☐	Female
☐	Male

Education: (Choose one.)

☐	Less than HS	☐	Graduate
☐	High School	☐	Higher studies
☐	Diploma	☐	

This work was previously published in Information Resources Management Journal, Vol. 21, Issue 4, edited by M. Khosrow-Pour, pp. 1-26, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 11
Factors Influencing the Use of Decision Support Tools of Enterprise Resource Planning Systems

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ABSTRACT

Over the past few years, the marketplace and the trade press have recognized the value derived from using enterprise resource planning (ERP) systems for decision making support. However, research studies have tended to concentrate primarily on the use of ERP systems on their transactional and record-keeping aspects. This study used the technology acceptance model (TAM) to evaluate the impact of a set of individual differences (demographics, computer self efficacy, and knowledge of the system), system characteristics (relevance, terminology and screen design), and perceived benefits of the system, on the intentions to use ERP systems for decision support. A field study was used to collect data from managers working in Bahraini enterprises that use ERP systems. The results indicate that individual differences concerning age, gender, level of education, and even computer self efficacy did not influence intentions of using the decision tools of ERP systems. The only individual difference that showed significant influence is the degree of knowledge of the system. In addition, both perceived shared benefits and system characteristics had significant influence on the intention to use the system for decision support tasks, through perceived ease of use and perceived usefulness. The chapt4er discusses the implications of these findings and ends with possible extensions of the study.

INTRODUCTION

Over the past decade, organizations around the world have spent billions of dollars implementing enterprise resource planning (ERP) systems. Motives of adopters of ERP systems have focused primarily on revolutionalizing transactions handling by improving business processes and integrating operations and data. The current generation of ERP packages holds the promise of improving online analytical capabilities to enhance the organization's business intelligence as well.

DOI: 10.4018/978-1-60566-962-5.ch011

ERP systems could be defined as comprehensive software packages that seek to integrate the complete range of business processes and functions in order to present a holistic view of the business from a single information and information technology architecture (Gable, 1998). Implementing an ERP system is a costly and risky project. The cost of a full implementation in a large international organization can easily exceed $100 million. A recent survey of 63 companies – with annual revenues ranging from $12 million to $63 billion –indicated that ERP projects cost $10.6 millions and take 23 months in average to complete (Umble & Umble, 2002). Moreover, their implementation environments are often very complicated. They usually require large scale business process reengineering (BPR) undertakings, complex technical arrangements for integrating the core ERP technology with any existing or future software, as well as careful management of the contributions of several participants in the projects such as: functional departments, consultants, business partners, and vendors. All these requirements and more, magnify project management challenges for such projects, making them prone to implementation failure.

Despite these challenges, investments in these systems are increasing, making the ERP software one of the fastest growing markets in the software business. In the nineties some statistics projected its eventual market size to be around $1 trillion by the year 2010 (Bingi et al., 1999). Moreover, expectations for keeping these interests in ERP investments are even bigger in the 2000s. This is because, though they were originally developed and implemented for transactional aspects, a growing need to use these systems for decision support has recently become clear Lately, these software packages are incorporating decision support tools in order to take advantage of data storage, access, scrubbing, and integration capabilities facilitated by ERP systems (Turban et al., 2005). On the other hand, the confluence of ERP and decision support technology has begun to draw the attention of the academia as well (Shafiei and Sundaram, 2004). Obviously ERP vendors, implementers, and researchers need to understand the factors that affect their usability. Based on this need, this paper's main objective is to identify the main contextual variables that influence the acceptance of decision support tools of ERP systems. Three groups of variables were introduced in our theoretical model: individual differences, perceived shared beliefs of the decision support benefits of these systems, and system characteristics.

Section 2 of this paper reviews prior literature on ERP and decision support. In addition, it provides a brief of TAM as the guiding basis for the theoretical framework of this research. Section 3 introduces the research model along with a discussion of the model variables. Section 4 describes the study's methodology. Section 5 reports findings on the factors that are found to be influencing the use of these systems. Section 6 concludes the study with a discussion of the main findings and suggestions for future investigations.

LITERATURE REVIEW

ERP and Decision Support

Very few studies have addressed issues related to incorporating ERP systems and decision support tools. This is mainly because ERP and decision support systems have independently evolved and adopted in the marketplace as well as in academia. Consequently, each subject has its own separate studies. On the other side, plenty of research efforts have been introduced for technology/information systems acceptance or usability. In the following paragraphs, we tried to briefly present the research most related to our study's main objective.

Starting with the ERP aspect, many researchers have provided frameworks and insights that tried to explain success of ERP systems implementation. We thought that these success factors' frameworks could be helpful in providing a basis for synthesiz-

ing an initial acceptance theory for incorporating ERP and DSS tools for our research. Akkermans and Van Helden (2002) and Al-Mashari et al. (2003) for example, used a case study approach to provide rich accounts of the implementation processes for some selected individual companies. Other studies used a statistical approach to develop and test different theoretical models that identify several critical success factors, using samples of firms that have recently implemented ERP systems (Hong & Kim, 2002; Bradford & Florin, 2003). Examples of factors tested in such studies are: top management support, effective communication, project management, business plan and vision, software testing and trouble shooting, and monitoring and evaluation of performance. Another important direction this literature has tried to examine is how such critical factors differ in their impact or contribution to success, according to the different stages in the life cycle of the ERP implementation project (Markus & Tanis, 2000; Rajagopal, 2002).

Previous studies concerning DSS use or adoption had other streams that could be used as well for building a relevant background for this study. For example, some researchers paid great attention to issues such as patterns of use or areas where such DSS tools are used and how these patterns affect perceived value and satisfaction (Vlahos et al., 2004). Others concentrated on how acceptance levels of these systems differ according to managers' individual differences, such as gender and cognitive and decision style (Lu et al., 2001; Bruggen and Wierenga, 2001). One important development in this area is the steady growth of business intelligence and business analytics technologies' industry, with revenues reaching into low billions, according to some statistics (Turban et al., 2005). Moreover, tools concerning data mining, data warehousing, and knowledge management systems are becoming easier to use and consequently more promising for higher levels of usability. One of the surveys concerning these developments showed that approximately 35% of corporate management and staff directly used data mining tools (Nemati and Barko, 2001).

The confluence of ERP and DSS is still in its initial stage, though clear interests could be cited. For example in a field study of six ERP implementations, Palaniswamy and Frank (2000) described organizations' need to digest the vast amount of information from the environment and make fast decisions. Shafiei and Sundaram (2004) explained that DSS tools take advantage of the data resident in ERP systems. Holesapple and Sena (2005), in their survey that examined the connections between ERP systems' objectives and decision support benefits, found that organizations did consider four objectives for decision support to be fairly important while planning their ERP projects. These objectives are: shifting responsibility of decision making, supporting interrelated decision making, supporting multiple persons working jointly on a decision, and supporting individual decision makers. On the other side, the survey showed that ERP systems do indeed provide substantial decision support benefits concerning the following: enhancing knowledge processing, improving competitiveness, reducing decision costs, and supporting multiparticipants' decision making.

Technology Acceptance Model

Identifying factors that determine user's adoption of information systems has drawn much attention in the last two decades. This is due to the realization that millions of dollars could be spent on these systems, while potential users may not even use them. Technology acceptance model (TAM) is an established model in explaining IS adoption behavior. It is based on theories in social psychology such as theory of reasoned action (TRA), and the theory of planned behavior (TPB). TAM has been frequently found to have better explanatory power than other models or theories used in the IS adoption subject (Davis et al., 1989; Taylor and Todd, 1995).

According to TAM, usage of an information system is determined by users' intention to use the system, which in turn is determined by users' beliefs about the system. There are two kinds of salient beliefs involved: perceived usefulness and perceived ease of use of the system. Perceived usefulness (PU) is defined as the extent to which a person believes that using the system will enhance his job performance. Perceived ease of use (PEOU) is defined as the extent to which a person believes that using the system will be free of effort. Furthermore, both types of beliefs are subjected to the influence of external variables. By manipulating these external variables, system developers can have better control over users' beliefs of the system, and subsequently, their behavioral intentions and usage of the system. A good review of this stream of research is provided by Lucus and Spitler (1999), and Legris et al. (2003).

TAM has been applied to a wide range of IS applications. However, very few have used it for complicated systems such as ERP. Amoako-Gympah and Salam (2003) – probably the first to extend using TAM in an ERP implementation environment – have examined the impact of training and project communications on shared beliefs about the benefits of the ERP technology and how these shared beliefs influence TAM core framework. Amoako-Gympah (2005), in another study, looked at the influence of prior usage, argument for change, intrinsic involvement, and situational involvement on PU and PEOU of TAM. Also Calisir and Calisir (2004), based on data obtained from 35 end users in 24 companies, found that PU and learnability could be significant determinants of end user satisfaction with ERP systems. In addition, PEOU and system capability seemed to affect PU, while user guidance seemed to influence both PU and learnability.

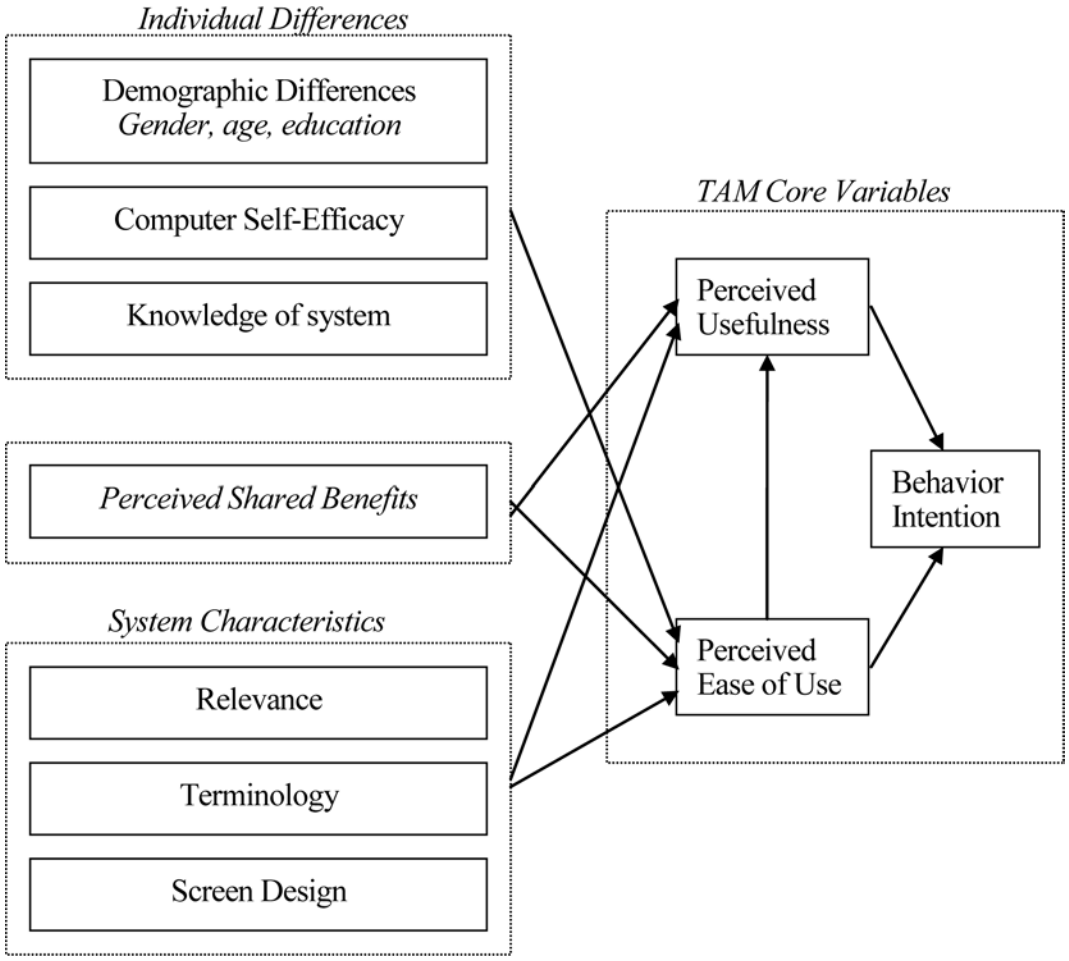
This paper represents an extension to this line of studies. From one side, it tries to contribute to the current interests in integrating ERP and decision support tools body of research. From the other side, it tries to meet the need to understand the main factors that affect the use of this side of the system. The current few studies which investigated the acceptance of ERP systems, concentrated on the general use of ERP systems, which is more oriented towards the classical transactional part of these systems. We believe that the decision support part of ERP systems requires separate investigation concerning its usability.

It is important to note here that using TAM for this research was not for the sake of introducing another TAM example. We came to a belief in the beginning of this study that measuring the intentions to use the system is more appropriate than measuring its real use. We expect that the use of the decision support tools accompanying ERP systems is still relatively limited, as these systems are traditionally considered as transactional systems. Moreover, using TAM had many advantages for such research studies. Firstly, it informs researchers of what types of contextual factors could be included and how their relationships might be. Secondly, it provides an important basis for comparisons and extensions with previous research in IS. Thirdly, many of the academics feel comfortable with TAM, though some still do not feel relaxed with the link between intentions to use the system and its real use. However the big previous bulk of research concerning TAM, indicates a high level of acceptance of the model, which eases understanding of any future extensions.

RESEARCH MODEL AND HYPOTHESES

Many factors have been selected by prior studies as potential predicators for IS use intentions. Examples are: top management support, project management capabilities, and BPR competencies. However, our main concern was to include only those which are specifically related to the decision support part of the system. This criterion made us eliminate many factors that seemed more ap-

Figure 1. Research model



propriate to the traditional transactional aspect of the system. In the end, three main categories of external variables have been selected, namely: individual differences, system characteristics, and shared beliefs about the benefits of the system. We thought that it is fairly logical to expect that managers' intentions to use such a system rely more on how they perceive its specific benefits to their work, how friendly and relevant this system is to use, and other items related to their individual characteristics. These three groups of variables have been emphasized in most of the classical TAM research studies (Agarwal & Prasad, 1999; Davis, 1989; Igbaria and Iivari, 1995; Venkatesh, 1999). The proposed research model includes three individual differences variables and three system characteristics, besides shared beliefs items about the benefits of ERP for decision support (see Figure 1) and the selection of which are supported by prior studies in the IS literature. The following is a discussion for these variables.

Individual Differences

Individual differences are believed to be most relevant to both the decision making process (Klenke, 2003; Lu et al., 2001; Smith, 1999) and information systems' use intentions (Mafe & Blas,

2006; D'ambra & Wilson, 2004; Lai & Li, 2005; Olson & Boyer, 2003; Kotey, 2006). In this study, we examined three variables concerning individual differences: demographics, computer self-efficacy (CSE), and knowledge of system.

The demographic variables or the personal characteristics selected for this research are: gender, age, and education. Previous research efforts showed how information systems' use intentions differ between men and women (Mafe & Blas 2006; Lai & Li, 2005); how differences in age influence users' levels of computer anxiety and consequently use intentions (Kotey, 2006; Lu et al., 2003); and how computerized information systems' use is related to the users' level of education (Olson & Boyer, 2003; Mafe & Blas, 2006).

Beside demographics, computer self efficacy is one of the classical individual differences, usually found as an important predicator for IT usage (Compeau and Higgins, 1995) and PEOU of information systems (Agarwal, 2000; Igbaria and Iivari, 1995). Knowledge of the system is another important individual difference that has been found as a significant contextual variable for IT/IS use intentions (Benbasat et al., 1986; Hong et al., 2002). Apart from TAM suggestions of what variables to include in the research model, considering individual differences is especially important for decision support systems, where higher levels of interactivity and mutual learning are expected to exist between the system and the user (Turban et al., 2005). Differences in individual characteristics will then influence how users interact with the system and consequently their use intentions.

According to TAM, individual differences usually influence PEOU, but not PU (Hong et al., 2002; Igbaria and Iivari, 1995), as shown in figure 1. Based on the above discussion, our related hypothesizes are:

H1a Using ERP systems for decision making will be perceived easier for male than for female managers

H1b Using ERP systems for decision making will be perceived easier for younger managers.

H1c Using ERP systems for decision making will be perceived easier for managers with more education

H2 Using ERP systems for decision making will be perceived easier for managers with higher levels of computer self-efficacy.

H3 Using ERP systems for decision making will be perceived easier for managers with higher levels of knowledge of the system.

System Characteristics

The main logic behind including system characteristics in this framework is that the study deals with a relatively complex system. Consequently, we expected higher influences to factors related to how friendly their interfaces are and how relevant their functions are to the users' main tasks. The relationships between system characteristics and TAM beliefs' constructs have been investigated in many studies (Venkatesh and Davis, 2000; Hong et al., 2002). Researchers usually use a general construct that represent this variable, such as "perceived system quality" (Igbaria et al., 1995) or "output quality" (Venkatesh and Davis, 2000). This study relied on Hong et al.'s (2002) three system characteristics to be investigated in this research, namely: relevance, terminology, and screen design,.

Relevance can be interpreted as the degree to which the system matches users' information needs. Terminology refers to the words, sentences, and abbreviations used by a system. Screen design is the way information is presented on the screen. Similar to individual differences, system characteristics are especially important for decision support systems, to facilitate higher levels of interactivity between the system and the user.

However, the difference between system characteristics and the individual differences variable, according to TAM previous studies, is

that it is expected to influence both PEOU and PU of TAM core constructs and not only PEOU as depicted in figure 1 (Davis, 1989). According to the previous arguments, we expect that:

H4a: Relevance of the ERP system will have a positive effect on perceived ease of use of the decision support tools of the system.
H4b: Relevance of the ERP system will have a positive effect on perceived usefulness of the decision support tools of the system.
H5a: Terminology clarity of the ERP system will have a positive effect on perceived ease of use of the decision support tools of the system.
H5b: Terminology clarity of the ERP system will have a positive effect on perceived usefulness of the decision support tools of the system.
H6a: Screen design of the ERP system will have a positive effect on perceived ease of use of the decision support tools of the system.
H6b: Screen design of the ERP system will have a positive effect on perceived usefulness of the decision support tools of the system.

Perceived Shared Beliefs of Benefits

A shared belief about the specific benefits of the system in the organization may play a significant role in shaping the usage intentions of that system. Obviously, this factor is important because the main benefits of ERP are traditionally referred to their transactional aspects. Therefore, it was included to investigate the items specifically related to the decision making benefits that the system may bring. It is different than the PU variable in TAM construct, which is usually used to measure the general usefulness of the system in question. Thus:

H7a Perceived shared beliefs of the decision making benefits of ERP systems will have a positive effect on perceived ease of use of the decision support tools of the system.
H7b Perceived shared beliefs of the decision making benefits of ERP systems will have a positive effect on perceived usefulness of the decision support tools of the system.

TAM Variables

Extensive research over the past two decades provided evidence of the significant effect of PEOU and PU on users' intentions to use an information system (Agarwal and Prasad, 1999; Davis et al., 1999; Hu et al., 1999; Venkatesh, 1999). These studies also showed that while PU has direct impact on use intentions, PEOU has direct and indirect impacts. Hence, we hypothesize that:

H8: Perceived usefulness will have a positive effect on behavior intention to use the decision support part of the ERP system.
H9a: Perceived ease of use will have a positive direct effect on behavior intention to use the decision support part of the ERP system.
H9b: Perceived ease of use will have a positive indirect effect on behavior intention to use the decision support part of the ERP system through its effect on perceived usefulness of the system.

METHODOLOGY

Study Context: The Kingdom of Bahrain

The Kingdom of Bahrain is a small Arabian island centrally located in the Arabian Gulf, with a monarchy rule form. Its economy depends on oil revenues. Facing declining oil reserves, Bahrain has turned to petroleum processing and refining imported crude. Also, it has transformed itself into an international banking center. Other important industries are aluminum smelting and

tourism. Current population is approximately 688 thousand residents of whom approximately 235 thousand are not nationals. For more details about the Kingdom of Bahrain, see http://www.odci.gov/cia/publications/factbook/geos/ba.html.

Measures

A survey methodology was used to gather data for this study. Straub's (1989) guidelines to validate the instrument of this research were followed. Items used in the operationalization of the constructs were drawn from relevant prior research and provided in Appendix A. One advantage of using TAM to examine the adoption of a specific information system is that it has well-validated measures. PEOU, PU, and behavior intentions constructs were measured by items, taken from the previously validated inventory of measures and modified to suit the current context (Agarwal and Prasad, 1999; Hong et al., 2002).

The CSE instrument developed by Compeau and Higgins (1995) was used in this research. Knowledge of the system was assessed by two items suggested by Davies (1997): familiarity with using the system and knowledge about using the system for the users' specific decisions problems. Items for measuring the three system characteristics were taken from Hong et al.'s (2002) user survey, and were rephrased for the context of the study's specific information systems. Perceived shared benefits were self developed based on related previous studies such as Holesapple and Sena (2005) and Amoako-Gympah, (2005). Likert scales (1~7), with anchors ranging from "strongly disagree" to "strongly agree", were used for all questions except for the items measuring CSE. The anchors of the items measuring CSE ranged from "not at all confident" to "totally confident". The mean of the scores over all questions provided the composite score for each variable. The adopted instrument, along with all its items, was discussed with three industry executives from three different organizations experienced with using ERP for decision making and with two faculties. Based on their feedback, minor changes to reflect the research settings were made in the instructions and wording of some of the items. The subjects who had participated in this convenience pre-test were excluded from the final data collection and subsequent study.

Sample and Procedure

Only 10 companies were found to have prior experience in ERP systems in Bahrain. To come up with this list of companies, Vendors' web sites (Arabian branches) were reviewed and brief telephone interviews were made with their representatives in Bahrain.. The IT manager of each

Table 1. Sample description - companies profile

Company	*ERP Vendor*	*Use period*	*No. of employees*
Batelco (Bahrain Telecom co)	SAP	3	1600
Asary (Arab Ship-building & Repair Yard)	Oracle	5	1200
Bahrain flour mills	Orion	1	100
Bapco (Bahrain Petroleum)	Oracle	3.5	3000
Aldhaen Craft	Oracle	3	200
GFH (Gulf Financial House)	Oracle	2	100
Alba (Aluminum Bahrain)	SAP	5	3000
Midal Cables	Oracle	4	310

company was contacted to help us come up with a list of potential interviewees for the study.

The targeted informants are all the managers who use ERP systems to assist him/her in decision making. There were no restrictions on the organizational level of the manager, whether in top, mid-management or operational level in the organization. Also, no restrictions were imposed on the functional activity where the decision makers work. The list of the potential informants had approximately 20 informants for each company. Consequently about 200 copies of the questionnaire were sent to the IT managers of these companies, who forward them to the targeted informants in their companies (Table 1).

Before answering to the questionnaire, respondents were asked whether they have enough experience in using the system for some decision making activity or not. Only 84 interviewees returned the questionnaire (a response rate of 42%) from 8 companies. Nine of the questionnaires were dropped because seven of them had incomplete answers. The other two came from two managers who have not used the system yet, as was indicated by one of the questions in the questionnaire. Table 1 shows the companies participating in the study, while Table 2 provides a profile of the respondents.

Table 2. Sample description - respondents profile

	Frequency	*Percentage*[a]
Gender	61	81
Male	14	19
Female		
Age		
Mean = 37. 7		
SD = 9.2		
Department	25	33
Accounting & finance	11	15
Information technology	7	9
Product managers	7	9
Product Marketing	6	8
Planning and project management	19	25
Other departments (Engineering, Logistics and Procurement, Production and Maintenance, Human Resources)		
Experience in management positions		
Mean = 9.3 years		
SD = 6.8		
Experience in using ERP in Decision making		
Mean = 4 years		
SD = 2.9		
Educational level	22	29
Master's degree	7	9
Post graduate diploma	38	50
Bachelor degree	9	12
Diploma (Associate Degree)		
Respondents from each type of business	33	44
Manufacturing (5 companies)	19	25.3
Oil (1 company)	16	21.3
Telecommunication (1 company)	7	9.3
Banking and finance (1 company)		

[a] Due to rounding the percentage may not add up to 100

Table 3. Summary statistics, and reliability and validity analysis

Measures	*Items*	*Mean*	*SD*	*Reliability (Cronbach's Alpha)*	*Validity:(Items loadings on single factors*[a]
Behavior Intention	2	5.7	0.9	0.82	0.57; 0.70
PU	3	5.6	0.9	0.91	0.79; 0.84; 0.83
PEOU	3	5.2	1.1	0.79	0.64; 0.60; 0.81
Relevance	2	5.0	1.3	0.86	0.74; 0.79
Terminology	2	4.9	1.1	0.73	0.82; 0.61
Screen Design	2	4.7	1.5	0.89	0.54; 0.72
Perceived Shared Benefits	8	5.4	0.8	0.88	0.77; 0.78; 0.59; 0.65; 0.59; 0.60; 0.82; 0.76
Knowledge of system	2	5.4	1.0	0.85	0.74; 0.75
Computer Self-Efficacy	8	4.9	0.9	0.78	0.71; 0.56; 0.90; 0.57; 0.76; 0.79; 0.87; 0.81

[a] Extraction method: Principal component analysis; rotation method varimax with Kaiser normalization; egienvalue = 1

Validity and Reliability

Reliability

Reliability is the consistency or precision of a measuring instrument that is the extent to which the respondent can answer the same or approximately the same questions the same way each time (Straub, 1989). The internal consistency reliability was assessed by calculating Cronbach alpha values. The results of the reliability test conducted for the study's constructs are summarized in the fifth column of Table 3. All alpha scores were above 0.70, which suggest an acceptable level of reliability for the study's constructs (Field, 2000).

Discriminant Validity

Since each variable was measured by multi-item constructs, a discriminant analysis should be employed to check the unidimensionality of the items. Discriminant validity was checked by conducting a factor analysis. In Table 3, discriminant validity was confirmed when items for each variable loaded onto single factors with loadings of greater than 0.5 (Nunnally, 1978). Table 3 provides the loadings of each item of the independent and the dependent variables. Nine factors emerged with no-cross construct loadings above 0.5, indicating good discriminant validity.

Based on these examinations of the psychometric properties of the scales, we conclude that each variable represents a reliable and valid construct (Field, 2000).

RESULTS AND ANALYSIS

The means and standard deviations of all the variables of the study are summarized in Table 3. A multiple regression analysis was employed to identify which variables made significant contributions to predicting the dependent variables: use intentions, PU, and PEOU, to test hypotheses H1- H9a. Also, a path analysis was used for hypothesis H9b. Path analysis is a regression-based technique widely used for studying the direct and indirect effects in models encompassing mediating variables, similar to the research model proposed in this study. The intercorrelation matrix (Table 4) was first examined to assure the validity of the regression analysis, looking for possible multicollinearity problem. All intercorrelations among exogenous variables were reasonably low.

Table 4. Correlation matrix between variables

Measures	*(1)*	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*	*(9)*	*(10)*	*(11)*	*(12)*
Behavior Intention (1)	1											
PU (2)	.59**	1										
PEOU(3)	.49**	.53**	1									
Relevance (4)	.33**	.46**	.35**	1								
Terminolog7 (5)	.40**	.44**	.50**	.49**	1							
Screen Design (6)	.38**	.35**	.48**	.68**	.69**	1						
Perceived Shared Benefits (7)	.39**	.39**	.50**	.38**	.33**	.40**	1					
Knowledge of system (8)	.25*	.40**	.35**	.49**	.68**	.59**	.25*	1				
Computer Self-Efficacy (9)	.11	.21	.14	.16	.06	.03	.22	.24*	1			
Gender (10)	-.02	.01	-.02	-.16	.00	-.10	.01	-.05	.04	1		
Age (11)	-.03	.04	.03	.04	.06	-.03	.04	.01	-.17	-.31**	1	
Education (12)	.04	-.12	-.16	-.05	-.03	-.12	-.09	-.04	.14	-.02	-.15	1

* $p < 0.05$; ** $p < 0.01$

Hair et al. (1995) suggest that values of $r > 0.80$ indicate a multicollinearity problem.

The results of the regression analysis, including *B* coefficient, *t*-statistic, and significance level for each independent variable, are reported in Table 5. The first regression model showed that both PU and PEOU were found to be significant determinants of the dependent variable namely, the intentions to use the decision tools of ERP systems. Also R^2 value of the model indicated that it explains 39% of the dependent variable total variance. However, the relative strength of their explanatory power was different. PEOU ($B = 0.46, p < 0.001$) was a much stronger predictor of managers use intentions as compared to PU ($B = 0.25, p < 0.05$). The results provided support for H8 (PU – use intention relationship); and H9a (PEOU– use intention relationship).

In the second regression model, PU was regressed on perceived shared benefits, system relevance, system terminology, and system screen design. This analysis yielded a regression function ($R^2 = 0.32, p < 0.001$) with 3 significant predicators: perceived shared benefits ($B = 0.23, p < 0.01$), system relevance ($B = 0.34, p < 0.05$), and system terminology ($B = 0.33, p < 0.05$). The results provided support for H4b (systems relevance – PU) H5b (system's terminology – PU); and H7b (shared benefits – PU). The findings however, failed to support H6b concerning the relationship between system screen design and PU.

Also a multiple regression method was applied to determinevariables influencing PEOU. The results reported in Table 5 showed that only system terminology ($B = 0.33, p < 0.05$), and perceived benefits ($B = 0.36, p < 0.01$) have significant effects on PEOU. These variables explained approximately 40 percent of the variance in PEOU. Based on these results, H5a (system terminology – PEOU), and H7a (perceived shared benefits – PEOU) were also supported. The analysis failed to support H1a, H1b, H1c, H2, H3, H4a and H6a. These concern the relationships between gender; age; education; computer self efficacy; knowledge of the system; system relevance; and system screen design, and PEOU.

Table 5. Multiple regression results

Dependent variables	R^2	*Independent variables*	*B*	*t*	*Sig.*
Behavior Intention	0.39***	PU	0.25	2.26	0.027*
		PEOU	0.46	4.25	0.000***
PU	0.32***	Perceived Shared Benefits	0.23	2.07	0.002**
		Relevance	0.34	2.51	0.014*
		Terminology	0.33	2.43	0.018*
		Screen Design	-0.27	-1.27	0.210
PEOU	0.40***	Perceived Shared Benefits	0.326	2.95	0.004**
		Relevance	-0.054	-0.395	0.694
		Terminology	0.33	2.155	0.035*
		Screen Design	0.175	1.04	0.302
		Knowledge of system	-0.066	-0.466	0.643
		Computer Self-Efficacy	0.082	0.756	0.452
		Gender	-0.028	-0.267	0.791
		Age	-0.004	-0.33	0.974
		Education	-0.116	-1.154	0.253

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Following the suggestions of Cohen and Cohen (1983), a hierarchical multiple regression was used to test the mediation hypothesis (H9b). I regressed behavior intention on PU in the first step, with PEOU in step two. The unique contribution of PEOU (in explaining behavior intention) was examined over and above the PU variable. Table 6 showed that the change in R^2 after introducing project success into the equation is significant (R^2 change = 0.043, $p = 0.01$), giving support to the proposed mediation hypothesis (H9b). Table 7 summarizes hypotheses testing results.

DISCUSSIONS, CONCLUSION, AND LIMITATIONS

This study tried to contribute to the emerging research efforts concerning the convergence of ERP systems and decision support tools. We tried to provide an understanding of the different variables that influence manager's use intentions, which expectedly impact their level of adoption and usability of these systems. Following the research main framework and its groups of variables, we discuss the results as follows.

Individual Differences

In contrast with our hypotheses and most of the prior research, all the individual differences that have been considered in the research model did not influence Bahraini managers' perceptions concerning ease of use of these systems. It is interesting to find that CSE was a non significant factor in this study. This might mean that managers do not see technical or computer skills as a significant obstacle anymore. Supporting this argument, the degree of managers' knowledge of the system was found to not be statistically influential as well. Using computer systems in the past might have been difficult or at least require significant training in order to convince users to adopt them. Even for simple systems such as email, word processing, and spreadsheets, prior research showed that sufficient computer skills

Table 6. Hierarchical regression results

Regression step 1			***Regression step 2***		***Change in R^2***
R^2	*p*		R^2	*p*	
0.349	0.000		0.392	0.027	0.043

Table 7. Hypotheses testing results

	PEOU		***PU***		***Behavior intention***	
	No.	Support	No.	Support	No.	Support
Gender	H1a	No	---	---	---	---
Age	H1b	No	---	---	---	---
Education	H1c	No	---	---	---	---
Computer Self-Efficacy	H2	No	---	---	---	---
Knowledge of system	H3	No	---	---	---	---
Relevance	H4a	No	H4b	Yes	---	---
Terminology	H5a	Yes	H5b	Yes	---	---
Screen Design	H6a	No	H6b	No	---	---
Perceived Shared Benefits	H7a	Yes	H7b	Yes	---	---
PU	---	---	---	---	H8	Yes
PEOU (direct)	---	---	---	---	H9a	Yes
PEOU (indirect)	---	---	---	---	H9b	Yes

were required (Agarwal and Prasad, 1999; Harrison and Rainer, 1992). At the present time, a new generation of managers who are immune from the difficulties of using information systems have taken over, and computer systems have become much easier than they were in the past. Moreover, using professional assistants to help managers in using advanced decision support systems is one of the common ways for bypassing the difficulty of directly dealing with such systems (Turban et al., 2005).

Besides the technical skills, the results showed that demographic differences were also not statistically influential in this research. It seems that managers nowadays are more confident in using computers than they were in the past. Their intentions to using such systems do not differ whether they are old or young, male or female, having higher or lower degrees of education. One limitation for the finding concerning gender is that females represent only 19% of the sample.

The previous findings simply suggest that implementation plans shouldn't have different programs for enhancing system adoption according to such individual differences. This would save our time and efforts for other more significant factors.

System Characteristics

Not all the three system characteristics had significant influence on TAM variables according to the results of this study. While system terminology had a significant effect on both PEOU and PU, system relevance had a significant effect only on PU. On the other hand, Screen design did not have any influence on either. These results suggest that the vendor of these packages should give more

emphasis to the terms, language, and expressions that managers use in their decision making activities, in order to enhance adoption levels of these systems. Although both screen design and terminology represent system interface, the results did not support the role of screen design on both TAM variables. This implies that what matters in these packages is its ability to reflect the language that managers use, and not imposing other technical or non related terminology that might distract their use of these systems.

On the other hand system relevance was found to have influence on PU, but not PEOU. It seems logical to find this influence on managers' perceptions of the usefulness of the system, as relevance is more related to the content of the system – not to the interface, as in the other two system characteristics. This also supports prior studies concerning the effect of system relevance on system use (Venkatesh and Davis, 2000).

Perceived Shared Beliefs

Consistent to our hypotheses, we found significant support to our expectations that shared beliefs in the benefits of the decision tools of ERP systems affect TAM constructs. This finding is especially important as ERP systems are generally known for their transactional aspects. Managers need to know the specific benefits of these systems for decision making. If management can take appropriate steps to positively influence the belief structure concerning decision making activities of these systems, this will then lead to more acceptance of ERP systems by the organization's managers.

It is clear from the results that this factor - besides system terminology - was found to be the most important influential factor of the study. Implementation programs should then give more attention to these two factors. Training and communication programs should help form these shared beliefs. Managers should directly understand how ERP decision tools provide such benefits.

The findings of this study have implications for developing usable ERP systems for decision making tasks. Considering the millions of dollars that have been invested in such systems worldwide, it is of paramount importance to ensure that managers will actually use them. In order to achieve this goal, attention must be placed in designing user-friendly interfaces that emphasize manager-familiar terminologies. At the same time, developers of ERP systems should keep in mind that, although these interface-related system features may appeal to users in the early stages, their final decision on whether to use a system or not, depend on the content of the decision tools of these systems. Specifically, it depends on how relevant these systems are to managers' decision problems.

On the other hand, implementation programs for these systems should have a strong training and communication scheme in order to provide clear understanding of the specific benefits of these systems to decision makers.

This research has several limitations. First, we did not incorporate actual usage behavior in the proposed model. However, this is not a serious limitation as there is substantial empirical support for the causal link between intention and behavior (Venkatesh and Davis, 2000; Venkatesh and Morris, 2000). Second, there may be other individual and external variables that may affect the intention to use these approaches. Future research can incorporate other variables into the research model. Potential individual differences include managers' cognitive styles and decision styles, which have been repeatedly used in TAM applications in previous cases (Hong et al., 2002; Harrison and Rainer, 1992). Some other contextual factors, such as IT capabilities, outsourcing, and degree of strategic focus, have been included in relevant research studies (Bhatt, 2000). Future research can examine whether these factors have any influence on the acceptance of decision tools of ERP systems.

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APPENDIX A

SURVEY INSTRUMENT

The different opinions are indicated by the numbers 1: strongly disagree; 2: disagree; 3: somewhat disagree; 4: neutral; 5: somewhat agree; 6: agree; 7: strongly agree.

Perceived Usefulness (PU)

1- Using the system in my job enabled me to accomplish tasks more quickly.
2- Using the system in my job increased my productivity.
3- Using the system enhanced my effectiveness on the job.

Perceived Ease of Use (PEOU)

1- I found it easy to get the system to do what I wanted it to do.
2- It would be easy for me to become skillful at using the system.
3- In general, I would find the system easy to use.

Use Intension

1- I intend to use the system.
2- I intend to increase my use in the future.

Computer Self Efficacy (CSE)

1- I could complete the job using the software even if there was no one around to tell me what to do.
2- I could complete the job using the software if I had only the software manuals for reference.
3- I could complete the job using the software if I had seen someone else using it before trying it myself.
4- I could complete the job using the software if I could call someone for help if I faced a problem.
5- I could complete the job using the software if someone else had helped me get started.
6- I could complete the job using the software if I had a lot of time to complete the required job.
7- I could complete the job using the software if I had just the built-in help facility for assistance.
8- I could complete the job using the software if someone showed me how to do it first.

Knowledge of the System

1- I am familiar with using the system.
2- I am knowledgeable in using the system to make my decisions.

Beliefs about Using ERP System for Decision Support

1- The system enhances decision makers' ability to tackle large-scale complex problems.

2- The system shortens the time associated with making decisions
3- The system reduces decision-making costs.
4- The system encourages exploration on the part of decision makers.
5- The system enhances communication among decision-making participants.
6- The system improves coordination of tasks performed by an individual making a decision.
7- The system improves satisfaction with decision outcomes.
8- The system improves organizational competitiveness.

Terminology

1- I understand most of the terms used throughout the system.
2- The use of terms throughout the system is consistent.

Screen Design

1- The system commands are well represented by buttons and symbols.
2- The layout of the screens is clear and consistent.

Relevance

1- The resources in the system relate well to my work
2- The system has enough resources for my work

Chapter 12
Software Quality Management:
Measurement and Research Directions

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ABSTRACT

While the value of the Capability Maturity Model (CMM), ISO 9000, and Total Quality Management (TQM) concepts in managing software quality has been widely acknowledged, shortcomings of these approaches have also been recognized. The current research synthesizes existing literature bases in CMM, ISO 9000, TQM, among others, to identify six critical factors of Software Quality Management (SQM) and then develops an instrument that can be used to measure critical factors of SQM. Validity and reliability are established by reviewing existing literature, testing a preliminary version of the instrument among a group of researchers and industry experts, and empirically testing a revised version of the instrument among a group of IS professionals. The authors conclude by addressing quality management research issues in the emerging open source software (OSS) paradigm.

INTRODUCTION

Recently, there has been an increasing emphasis on quality in developing software (Duggan, 2004; Harter et al. 2003; Jureta et al. 2009; Prajogo & Sohal, 2006; Tarvo, 2009). The quality of a software system is widely accepted as its conformance to customer requirements (Kan et al., 1994). The interest in quality is heightened as more system failures are attributed to issues in software quality that often lead to higher maintenance costs, longer cycle times, customer dissatisfaction, lower profits, and loss of market share (Arthur, 1993; Gopal et al., 2002; Kan et al., 1994; Tarvo, 2009). Although the importance of quality is acknowledged, managing quality efforts remains a major challenge in software development. In this context, software quality management refers to the process of carrying out key management practices necessary for achieving software quality.

The problems associated with inadequate software quality belie the amount of research on

DOI: 10.4018/978-1-60566-962-5.ch012

how software quality should be managed. Such normative work typically reports software quality management practices of successful companies by consultants, researchers, and managers. For example, Kan et al. (1994) discuss software quality in the context of Total Quality Management (TQM). Although the TQM philosophy in general emphasizes continuous improvement in quality, various TQM advocates prescribe a diverse array of techniques for quality management. Several authors present evidence of using TQM to improve software quality (e.g., Arthur 1993; Dunn & Ullman, 1994; Issac et al. 2006; Prajogo & Sohal, 2006; Manz & Stewart 1997; Subramanian et al. 2007; Victor et al., 2000). For instance, Ravichandran and Rai (2000) apply TQM principles to information systems development and derive a set of scales for assessing quality constructs. Others have acknowledged differences between soft (behavioral) TQM factors such as employee commitment and hard (technical) TQM such as statistical testing and their implications for quality performance (e.g., Rahman et al., 2005). Still others have examined the mediating role of TQM on the relationship between firm strategy and firm performance (Prajogo & Sohal, 2006). TQM, however, represents only one stream of research applicable to the management of software quality.

Software quality management is also discussed in the context of ISO 9001, ISO 9000-3, and SPICE (Jenner, 1995; Jung, 2005; Kehoe & Jarvis, 1996; McManus & Wood-Harper, 2007; Pino et al., 2008; Yoo et al., 2006). By achieving ISO certification, an organization is able to conduct business with customers or vendors who require that their partners adhere to accepted quality standards. However, because of possible disruption of normal operations and long duration of the auditing process, the costs involved in ISO certification could be considerable to some organizations. Moreover, because ISO 9001 only defines minimum qualifications a firm needs to achieve for certification (Bamford et al., 1993), it lacks support for continuous improvement in software quality (Coallier, 1994). In addition, ISO 9001's high level of abstraction has caused auditors to interpret it in different ways (Paulk, 1995).

The Capability Maturity Model (CMM[1]) developed by Software Engineering Institute (SEI) details a well-defined approach to software process improvement (Harter et al., 2000; Manzoni & Price, 2003; McManus & Wood-Harper 2007). While ISO 9000 highlights a more inter-organizational approach (e.g., vendor relationships) to managing quality, CMM takes a more intra-organizational strategy to quality management. Although CMM has been used in the industry as a means to assessing software process maturity, there is some criticism of its 5-level maturity model. For example, Saiedian and Kuzara (1995) claim that CMM is not an exhaustive model in that it does not address several software management and engineering practices crucial for project success and that because of CMM's roots in the governmental and defense-oriented software arena, its assumptions may not necessarily hold true in the commercial sector. Furthermore, Stelzer et al. (1997) highlight that CMM lacks a solid understanding and an explicit model for explaining the causes and effects of software quality management. More recently, Niazi et al. (2005a) observe that because of the complexity of CMM, little attention has been paid to its implementation, resulting in limited success in many software process improvement efforts. Notwithstanding their shortcomings, ISO 9000 and CMM have helped several organizations improve their ability to develop quality software (Harter et al., 2000). More recently, the emergence of the Capability Maturity Model Integration (CMMI) and ISO's SPICE typify the continued importance of the software process (Chrissis et al., 2003; Jung, 2005; Niazi, Wilson, & Zowghi, 2005b; Yoo et al., 2006). Specifically, CMMI provides guidance for improving the organization's processes, and managing the development, acquisition and maintenance of products and services. On the other

Table 1. Strengths and weaknesses of TQM, CMM, and ISO 9000

	TQM	CMM	ISO 9000
Strengths	* Has a rich history in general management literature. * Time tested and proven in general quality management.	* Widely accepted in the industry. * Continually evolving to address intricacies of advances in software development.	* ISO is the internationally accepted standard for quality where as ISO 9000 related to the software quality aspect. * Pays particular attention to vendor / supplier agreements.
Weaknesses	* Although applied to the IS context, with a few exceptions such as Ravichandran and Rai (2000), instruments for measuring critical factors of quality management have not widely emerged. * Moreover, measures such as those of Ravichandran and Rai take micro-focus on software quality management.	* Theoretical basis for CMM practice is generally lacking. * Considerable up front investment is needed to implement CMM in software quality improvement initiatives.	* Defines the minimum qualification a firm needs to achieve for certification, and hence lacks support for continuous improvement. * Takes a more inter-organizational (e.g., firm/vendor) focus that emphasizes contractual obligations in quality management (as the expense of critical factors such as process, management commitment, etc.). * Similar to CMM, considerable up front investment is needed to implement ISO 9000 software quality improvement initiatives.

hand, SPICE provides an international standard for software process assessment. Table 1 provides a brief overview of strengths and weaknesses of TQM, CMM, and ISO 9000.

In spite of the knowledge derived from past work on software quality management, there are at least two issues that, if addressed, may enhance knowledge in software quality management. First, with the exception of CMM and ISO 9000, the majority of existing literature on software quality management is case-based and company-specific, and therefore its generalizability is questionable. Moreover, some have acknowledged difficulties in implementing established approaches such as CMM (e.g., Niazi et al., 2005a). Second, past literature has generated relatively few measures for effective software quality management practices. Despite the fact that most software developing firms collect quality performance measures such as customer satisfaction, little work has been done in generating an instrument to measure the critical factors of software quality management. For example, the need to focus on the customer has been identified as one of the key factors in software quality management (Lin & Shao, 2000), but no operational measures are available for this critical factor. Moreover, instruments put forth by authors such as Ravichandran and Rai (2000) take a more micro focus on process improvement.[2]

Against this backdrop, our research synthesizes existing literature by identifying six critical factors of software quality management and then develops and empirically validates an instrument that can be used to measure those critical factors. A critical factor is defined as a set of related management practices that is essential to developing quality software. The contribution of our research is the development and empirical validation of an instrument that is relatively easily utilized by both practitioners and researchers in identifying critical factors of software quality management.

On the one hand, researchers can use the instrument to better understand industry practices in managing software quality and to develop theories and models that relate critical factors (e.g., management practices, processes) of software quality management to the quality of the software being built. For example, with a thorough understanding of critical factors of software quality management, researchers will be able to

map management practices with software quality criteria (e.g., correctness, accuracy, reliability, etc.). On the other hand, practitioners can use the instrument to identify strengths and weaknesses of their software quality management practices. For example, strengths and weaknesses in quality management practices can be identified by administering the instrument among team members of various software projects within a firm and then contrasting instrument scores between higher performance (i.e., quality) software products and those of lower quality. Managers can then more ably manipulate the relevant factors to improve software quality.

This paper is organized as follows. In the next section, we address the relevance of quality management research in manufacturing and service industries to software. Six critical factors of software quality management are presented in the subsequent section. Next, the methods used in developing and validating the instrument are described. Then, implications and limitations of this research are discussed. In our conclusion, we address quality management research issues in the emerging open source software (OSS) paradigm.

CRITICAL FACTORS OF SOFTWARE QUALITY MANAGEMENT

To identify critical factors in software quality management, a systematic study of the existing literature was conducted. Accordingly, we focused on those articles and books that were obtained from a computer-based search on ABI/Inform, Business Abstracts, Business Source Elite and CARL periodical databases, and from two online library databases. Special attention was paid to synthesizing quality attributes of CMM, ISO 9000, and TQM. The review of the extant literature provided us with a clear understanding of the universe of the software quality management (practices). Using a judicious process of grouping similar requirements, they were placed into a set of coherent categories. It was revealed that the requirements for effectively managing software quality may be categorized into six critical factors. They are top IS management commitment, education and training, customer focus, process management, quality metrics, and employee responsibility. These critical software quality management determinants are discussed briefly below. Our empirical research then explores the validity of these factors.

Management Commitment

This construct refers to top information systems (IS) management commitment to developing quality software. Several authors discuss the importance of management commitment in the context of TQM (e.g., Arthur, 1993; Dunn & Ullman, 1994; Issac et al. 2006; Kan et al., 1994; Ravichandran & Rai, 2000; Subramanian et al., 2007). Without management support, any quality program is unlikely to succeed (Gopal et al., 2002; Horch, 2003). Management responsibility to software quality is also a crucial requirement for ISO 9000-3 (Kehoe & Jarvis, 1996). Special programs such as *Excellence Council* and *Quality Week* have helped IBM get its managers committed to quality (Kaplan et al., 1995). These authors identify the need for management commitment to quality in terms of resource allocation, staffing, and providing the necessary leadership to create an overall quality culture. Sample items might include, top IS management "assumes responsibility for quality performance" and "is evaluated on quality performance."

Education and Training

This construct refers to provisioning of quality-related education and training for IS personnel and management. The importance of education and training is also highlighted in TQM (Cortada, 1995; Dunn & Ullman, 1994; Issac et al., 2006;

Ravichandran & Rai, 2000; Subramanian et al., 2007). ISO 9000-3 requires that quality-related training and education be provided to the IS staff (Kehoe & Jarvis, 1996). Quality education, leadership workshops, and quality publications have been effective in raising employees' knowledge of quality improvement (Gopal et al., 2002; Kaplan et al., 1995). Such literature identifies the need to provide both managers and developers with the necessary education and training in quality, statistical techniques, and metrics as a prerequisite to building quality software. Sample items might include "quality-related training is provided for IS personnel" and "resources are provided for quality-related education and training."

Customer Focus

This construct refers to the practice of focusing on customers who are any internal or external constituents for whom the software is developed. Kan et al. (1994) and Issac et al. (2006) emphasize the need to achieve total customer satisfaction through studying customer wants and needs, gathering customer requirements, and measuring customer satisfaction. Software quality aspirations are more likely to be achieved with a greater emphasis on customer satisfaction (Lin & Shao, 2000), which is often assessed with customer surveys (Kaplan et al., 1995). Arthur (1993) posits that customer satisfaction should be the main focus of all quality improvement efforts, which is consistent with both TQM's and ISO 9000-3's emphasis on customer focus. In addition, techniques such as quality function deployment (QFD) are heralded as a vehicle to help software developers hear the "voice of the customer" (Haag et al., 1996). The aforementioned authors jointly advocate the use of structured techniques to elicit customer needs during the early requirements analysis phase, feedback reports to get customers involved throughout the entire software development process, and surveys to measure customer satisfaction during the subsequent operational phase. Sample items might include "customer requirements are completely elicited in developing software" and "customer requirements are traced and referred back to throughout the software development process."

Process Management

Process management is the practice of managing the software development process. Process management increases visibility into the software process, and therefore helps reduce process variations, enhance the predictability of software quality, and facilitate process improvement (Harter et al., 2000; Havelka, 2003; Issac et al., 2006; Kaplan et al., 1995; Kehoe & Jarvis, 1996; Manzoni & Price, 2003; Ravichandran & Rai, 2000). The critical nature of the software process is further highlighted in the CMM. CMM was designed to assist software developing firms identify their current process maturity and, as a result, select strategies for process improvement (Paulk et al., 1993). Advocates attest that process maturity is linked to the quality of the software developed (Cook & Campbell, 1979; Manzoni & Price, 2003).

TQM identifies continuous process improvement as a precursor for developing quality software (e.g., Dunn & Ullman, 1994). Process management is further highlighted in ISO 9000-3 (Kehoe & Jarvis, 1996). Kaplan et al. (1995) advocate a more proactive approach to constantly improving the software process. These authors prescribe a process management strategy that involves the use of process benchmarking, configuration management, inspections and reviews, testing, CASE tools, standards and guidelines, defect prevention and analysis, statistical process control, and reuse. Sample items might include "software processes are documented," "a comprehensive testing program is utilized to validate the software" and "software process is emphasized over expediency."

Quality Metrics

The discipline of software metrics entails identifying various attributes that need to be measured and determining how to measure them in developing quality software (Gopal et al., 2002). Kan (2002) identifies 3 types of software metrics: product metrics (e.g., customer satisfaction), process metrics (e.g., defects identified during code inspections), and project metrics (e.g., scheduling). Software metrics give management the ability to make informed decisions (Gopal et al., 2002; McManus & Wood-Harper, 2007; Subramanian et al., 2007). Importance of software metrics is also stressed in TQM and ISO 9000-3 (e.g., Arthur, 1993; Cortada, 1995; Dunn & Ullman, 1994; Issac et al., 2006; Kehoe & Jarvis, 1996). However, Jenner (1995) highlights the need to have quality measures that are both cost effective and easily understood. The foregoing authors identify attributes of a sound quality metrics program as the availability and utilization of quality metrics, collection and analysis of data regarding quality, utilization of statistical techniques in analyzing data regarding quality, and coupling of quality metrics with the software development process. Sample items might include, quality metrics "are utilized" and "are tightly coupled with the software development process."

Employee Responsibility

The TQM philosophy requires employee empowerment as well as total employee involvement and commitment (Arthur, 1993; Duggan, 2004; Issac et al., 2006; Ravichandran & Rai, 2000; Subramanian et al., 2007). Kaplan et al. (1995) in advocating employee empowerment define it as sharing power and increasing autonomy throughout the organization. Rahman and Bullock (2005) contend that besides hard TQM factors such as statistical testing, soft TQM factors such as employee commitment to quality play a key role in quality management. ISO 9001 further emphasizes the value of employee contribution to software quality. For instance, personnel practices such as the use of teams and employee feedback, and the evaluation of processes instead of people are claimed to facilitate the development of quality software (Cortada, 1995). Horch (2003) argues that employees themselves must act as quality champions. These experts identify the need to implement quality teams, get employees involved in software quality matters, and reward them for their efforts. Sample items might include, IS personnel are "held responsible for quality performance" and "rewarded for quality performance."

Although the critical factors of software quality management identified above are grounded in the literature, the validity of any instrument developed in assessing these factors has to be empirically tested. The next section describes the development and validation process of the proposed instrument.

METHODOLOGY

The objective of this study was to develop and validate an instrument for measuring critical factors of software quality management. To achieve this goal, a 3-phase process was adopted. During Phase 1, a.) domain and dimensionality of the construct were identified; b.) sample items were generated; and c.) content validity was assessed. As described earlier, a review of the relevant literature revealed six critical factors of software quality management. To assess the appropriateness of the six critical factors derived from the extant literature, we sought the services of 10 IS research scholars and industry experts. They further verified that the six critical factors are representative of the quality management universe (a. domain and dimensionality of the construct identified). For each critical factor, the authors generated a set of items to measure that critical factor resulting in a six-factor 76-item instrument (b. sample items generated). In deriving items for the six critical

factors, we systematically consulted books and articles in the software quality management literature. For instance, with respect to management commitment, literature suggests that top managers are held accountable for quality performance. Accordingly, for this critical factor, the authors derived a set of items such that they encompass the corresponding domain.

The 76-item preliminary version of the instrument was then tested among 10 researchers and industry experts who are well versed on the topic (c. content validity assessed). These individuals were requested to thoroughly analyze the item list in regards to domain and dimensionality of each dimension as well as the appropriateness and accuracy of items within those dimensions. The two authors independently evaluated their comments. Evaluation was based on an *a priori* set of rules agreed to by both authors. Example rules on which the evaluation was based included incorporating common suggestions from the researchers and industry experts, using words and phrases that are easier to understand, etc. The few differences that emerged between the authors were resolved through mutual agreement. During phase 1, dimensions as well as the items within those dimensions were revised in an iterative manner as the underlying construct was better understood. Consequently, the instrument was revised to a 6-factor 54-item scale (see *Appendix*).

The population of interest is IS professionals at various levels of an organization involved in different aspects of software development. Accordingly, in Phase 2, the revised version of the instrument was administered to all IS professionals in the Midwest charter of the Association of Information Technology Professionals (AITP). This sample represents a cross-section of IS professionals in the U.S. The instrument and personalized cover letter were sent to each of the 957 members in this region of the association. The respondents were requested to answer each item in the instrument on a five-point Likert scale ranging from "strongly disagree" to "strongly agree." One month after the initial mailing, a second copy of the instrument and letter were sent to non-respondents. Two months subsequent to the first mailing, a reminder letter was sent to remaining non-respondents. A total of 152 surveys were completed and returned while 91 surveys were non-deliverable (e.g., invalid address, person no longer with the firm). This resulted in an 18% response rate.[3]

According to Pinsonneault and Kraemer (1993), two-thirds of the IS surveys at the individual level had a sample size less than 150 and a significant number of IS surveys had a low response rate. Considering the unsolicited nature of the field survey, the length (4-pages) of the instrument, and the sheer number of research surveys targeted at IS professionals, the response rate was deemed satisfactory and quite comparable to other similar studies in information systems (Raho et al., 1987). However, all possible efforts must be undertaken to maximize the sample size in order to minimize any sampling error (Salkind, 2002).

In order to assess possible nonresponse bias, 50 non-respondents were randomly selected for comparison with respondents. In assessing nonresponse bias, known values of the population are often compared with those obtained from respondents (e.g., Armstrong & Overton, 1977). Hence, firm size and sales figures for non-respondents were obtained from one or more of the following sources: state-wide manufacturing and service directories, Standard and Poor's register of corporations, and Dun & Bradstreet million dollar directory. No significant difference between the two groups was found for firm size (i.e., number of employees) ($F = .562$, $p = .454$) or logarithmically transformed sales ($F = .077$, $p = .781$), suggesting that there was no nonresponse bias.

The respondents were mostly top (34%) and middle (47%) level managers, and the firms they represent were primarily in manufacturing (28%) and financial services (25%). The remaining organizations were involved in IT consulting, government, healthcare, and education. The average

size and sales of the firms were approximately 10,038 employees (median: 1,500) and $2.1 billion (median: $200 million), respectively. Figure 1 summarizes biographical information pertaining to the respondents and organizational information concerning their corresponding firms.

Reliability

During phase 3, the reliability and validity of the instrument were assessed. Internal consistency (Cronbach's alpha) which measures the homogeneity of items within each critical factor was chosen to assess reliability. Reliability coefficients (i.e., Cronbach's alpha) for the six factors ranged from .80 to .96. Because alpha values greater than .7 are considered acceptable (Cronbach, 1951; Nunnally, 1978), each of the six critical factors was deemed reliable.

Item to Critical Factor Correlations

An analysis was performed to determine whether items within each critical factor were assigned

Figure 1. Summary of respondents and the corresponding firms (n = 152)

Respondents:

Rank:

Top Managers	34%
Middle Managers	47
Non-managers	18

Experience:

CIO	2.9 years
Project Manager	5.2
Quality Manager	1.0
Developer / Analyst	9.0
Quality Engineer	0.2
Other	2.8

Firms:

Primary Industry:

Manufacturing	28%
Financial Services	25
IT Consulting	13
Government	10
Healthcare Services	6
Educational	4
Other	14

Industries for which Software is Developed:

Manufacturing	36%
Financial Services	35
Government	20
Healthcare Services	16
Educational	11
Other	24

Group for whom Software is Developed:

Internal Customers	59%
External Customers	11
Both	28
Don't Know	1

Size of the entire firm (number of employees):
Mean: 10,038 Median: 1,500

Size of the IS department (number of IS employees):
Mean: 532 Median: 37

Annual sales revenue of the entire firm:
Mean: $2.1 billion Median: $200 million

Annual budget of the IS department:
Mean: $41 million Median: $2.1 million

appropriately to that factor. Correlations between items and each factor can be used for this purpose (Nunnally, 1978). Table 2 reports item to critical factor correlations. Critical factor (i.e., column) values represent the mean of all items within a particular critical factor. Note that most items within a particular critical factor have relatively high correlation values with that critical factor and relatively low correlation values with all other critical factors. Those items that did not exhibit relatively high item-to-critical factor correlations were marked for deletion. Specifically, we looked at instances where a particular item did not correlate highly with its own factor, but instead correlated relatively highly with other factors. For instance, "Customer Focus #5" had a .61 correlation with customer focus factor and .53 and .51 (relatively high) correlations with two other factors, namely, employee responsibility and management commitment. Because this item not only correlated poorly with customer focus, but also correlated relatively highly with two other unrelated factors, it was subsequently deleted from the instrument. The other items selected for deletion included Process Management #3, #9, #11, #12, and #13. Therefore, it can be concluded that the remaining 48 items were appropriately assigned to one of the six critical factors. Furthermore, because the remaining items had relatively high correlations with its own factor and relatively low correlations with the other factors, each factor was deemed to be unidimensional.

Validity

In instrument validation, three types of validity are generally considered: content, construct, and criterion. Content validity is defined as the extent to which scale items represent the universe from which they are drawn (Cronbach, 1971). Recall that the content validity was established through review of literature and evaluation of the initial instrument by a group of researchers and industry experts. Construct validity is the extent to which an instrument measures the theoretical construct it is supposed to measure (Cook & Campbell, 1979). Construct validity of an instrument can be assessed in terms of convergent validity which refers to the extent to which multiple measures of a construct concur with each other and discriminant validity which refers to the extent to which different measures of a single construct are distinct from each other (Campbell & Fiske, 1959).

Construct validity was assessed in a 2-step process. First, the revised 48-item instrument was factor analyzed. Factor analysis has been used extensively to assess construct validity (e.g., Moore & Benbasat, 1991). Principal component analysis with Varimax rotation was employed, and components with Eigen values greater than 1.0 were retained (Stevens, 1986). The rotated factor matrix was examined for items which were too complex (i.e., items that did not load notably on a single component) (Moore & Benbasat, 1991). Factor analysis was conducted in an iterative manner until no more complex factors were present. Table 3 illustrates the factor analysis iterations, the number of components that emerged, and items that were identified as too complex, and therefore selected for deletion. Further support for eliminating items without a common core is provided by (Churchill, 1979; Sethi & King, 1991). After the fourth iteration, only 36 items remained and the six components representing these items accounted for about 72% of the variance in the data set. The fact that the items within a particular critical factor loaded only on one of the six factor analysis' components provides tentative support for construct validity (see Table 4).

Second, the revised 36-item six factor instrument was used to assess convergent and discriminant validity. It has been argued that an instrument has convergent validity and discriminant validity when the correlations between the scales are significantly different from zero and significantly different from one, respectively (Bagozzi, 1980; Smith et al., 1996). As shown in Table 5, correlations between the six factors are significantly

Table 2. Item to critical factor correlations

		Factor					
	Item	1	2	3	4	5	6
Factor 1: Top IS Management Commitment	1	**0.81**	0.37	0.51	0.42	0.24	0.51
	2	**0.79**	0.37	0.52	0.52	0.34	0.63
	3	**0.84**	0.47	0.53	0.51	0.34	0.64
	4	**0.86**	0.49	0.53	0.57	0.39	0.66
	5	**0.79**	0.40	0.56	0.51	0.31	0.63
	6	**0.81**	0.59	0.45	0.52	0.33	0.61
	7	**0.83**	0.42	0.53	0.53	0.34	0.60
	8	**0.79**	0.51	0.46	0.56	0.39	0.57
	9	**0.84**	0.54	0.57	0.59	0.40	0.64
Factor 2: Education and Training	1	0.38	**0.66**	0.35	0.43	0.21	0.36
	2	0.50	**0.91**	0.33	0.51	0.43	0.52
	3	0.58	**0.86**	0.43	0.55	0.42	0.54
	4	0.41	**0.80**	0.37	0.47	0.53	0.51
	5	0.43	**0.84**	0.30	0.47	0.60	0.52
	6	0.48	**0.86**	0.41	0.52	0.45	0.52
Factor 3: Customer Focus	1	0.43	0.24	**0.71**	0.41	0.11	0.32
	2	0.46	0.20	**0.72**	0.42	0.09	0.38
	3	0.47	0.34	**0.73**	0.50	0.26	0.48
	4	0.29	0.18	**0.60**	0.33	0.21	0.35
	5	0.51	0.41	**0.61**	0.47	0.45	0.53
	6	0.46	0.36	**0.68**	0.52	0.37	0.45
	7	0.37	0.35	**0.73**	0.45	0.16	0.34
Factor 4: Process Management	1	0.40	0.48	0.47	**0.74**	0.47	0.46
	2	0.40	0.49	0.35	**0.72**	0.52	0.51
	3	0.30	0.39	0.21	**0.60**	0.54	0.35
	4	0.49	0.52	0.54	**0.77**	0.47	0.54
	5	0.55	0.50	0.50	**0.71**	0.40	0.54
	6	0.46	0.32	0.47	**0.59**	0.34	0.47
	7	0.41	0.41	0.51	**0.70**	0.44	0.46
	8	0.40	0.33	0.43	**0.61**	0.34	0.48
	9	0.34	0.51	0.32	**0.67**	0.64	0.52
	10	0.16	0.28	0.24	**0.53**	0.36	0.31
	11	0.57	0.30	0.51	**0.66**	0.36	0.53
	12	0.55	0.38	0.52	**0.65**	0.45	0.60
	13	0.51	0.32	0.51	**0.58**	0.35	0.53
	14	0.50	0.38	0.50	**0.76**	0.50	0.58
Factor 5: Quality Metrics	1	0.18	0.37	0.11	0.44	**0.83**	0.36
	2	0.34	0.50	0.27	0.60	**0.91**	0.50

Table 2. continued

	3	0.38	0.44	0.30	0.53	**0.84**	0.54
	4	0.49	0.51	0.36	0.64	**0.88**	0.61
	5	0.35	0.52	0.35	0.61	**0.86**	0.52
	6	0.34	0.49	0.37	0.60	**0.89**	0.52
	7	0.41	0.48	0.35	0.60	**0.88**	0.49
	8	0.30	0.42	0.28	0.52	**0.87**	0.50
	9	0.47	0.48	0.39	0.66	**0.84**	0.58
Factor 6: Employee Responsibility	1	0.48	0.25	0.40	0.44	0.27	**0.69**
	2	0.52	0.29	0.43	0.49	0.33	**0.76**
	3	0.55	0.36	0.47	0.55	0.34	**0.73**
	4	0.51	0.36	0.43	0.47	0.31	**0.73**
	5	0.68	0.56	0.50	0.59	0.43	**0.81**
	6	0.61	0.63	0.47	0.63	0.53	**0.75**
	7	0.51	0.59	0.42	0.54	0.61	**0.72**
	8	0.58	0.49	0.48	0.62	0.55	**0.82**
	9	0.57	0.47	0.43	0.59	0.54	**0.73**

Table 3. Factor analysis results

Iteration	Number of Components	Items Selected for Deletion
1	9	EDTRAIN #1, PROMGT #6, EMPRESP #5, #6, #7, #8
2	8	CUSTFOC #1, PROMGT #5, EMPRESP #9
3	7	CUSTFOC #6, PROMGT #2, PROMGT #10
4	6	none

Legend:
EDTRAIN Education and Training
CUSTFOC Customer Focus
PROMGT Process Management
EMPRESP Employee Responsibility

different from both zero ($p < .05$) and one ($p < .05$). Therefore, the six factors are all measuring some aspect of the same construct (convergent validity), but measuring a unique aspect of that construct (discriminant validity).

Criterion validity determines the extent to which an instrument estimates present performance or predicts future performance (Nunnally, 1978). Criterion validity of the instrument was assessed by examining the coefficients of determination for the six factors and quality performance. Because it was difficult to obtain comparable objective measures across different types and sizes of firms in the sample, a set of self-reported subjective measures was chosen as a proxy for software quality performance. This is consistent with Saraph et al. (1989) who also used subjective measures due to the difficulty in obtaining viable objective measures. Moreover, software quality has shown to affect user satisfaction, and therefore

Table 4. Final factor analysis matrix

		Components							
	Item	**1**	**2**	**3**	**4**	**5**	**6**		
Top IS Management Commitment	1	**0.79**	0.09	0.21	0.07	0.05	0.14		
	2	**0.67**	0.08	0.24	-0.01	0.17	0.40		
	3	**0.78**	0.18	0.13	0.07	0.14	0.25		
	4	**0.78**	0.18	0.14	0.21	0.17	0.14		
	5	**0.70**	0.11	0.26	0.11	0.12	0.22		
	6	**0.68**	0.41	0.10	0.15	0.10	0.13		
	7	**0.78**	0.13	0.18	0.08	0.17	0.13		
	8	**0.71**	0.22	0.02	0.30	0.18	0.06		
	9	**0.71**	0.24	0.12	0.27	0.17	0.18		
Education and Training	2	0.26	**0.83**	-0.01	0.17	0.18	0.14		
	3	0.38	**0.75**	0.12	0.19	0.17	0.04		
	4	0.13	**0.74**	0.11	-0.01	0.39	0.12		
	5	0.19	**0.74**	0.01	-0.02	0.45	0.09		
	6	0.25	**0.73**	0.11	0.27	0.22	-0.02		
Customer Focus	1	0.27	0.08	**0.72**	0.22	-0.05	0.07		
	2	0.30	-0.01	**0.77**	0.17	-0.06	0.17		
	3	0.22	0.17	**0.72**	0.25	0.09	0.15		
	4	0.09	0.03	**0.58**	0.05	0.15	0.16		
Process Management	1	0.13	0.25	0.17	**0.68**	0.28	0.10		
	4	0.23	0.32	0.24	**0.50**	0.27	0.15		
	7	0.17	0.12	0.24	**0.70**	0.27	0.06		
	8	0.17	0.04	0.11	**0.70**	0.15	0.25		
	14	0.27	0.05	0.21	**0.61**	0.32	0.24		
Quality Metrics	1	0.00	0.12	-0.11	0.09	**0.85**	0.00		
	2	0.12	0.21	-0.01	0.11	**0.89**	0.03		
	3	0.20	0.11	-0.04	0.19	**0.77**	0.14		
	4	0.28	0.15	-0.02	0.26	**0.78**	0.16		
	5	0.06	0.28	0.15	0.11	**0.80**	0.14		
	6	0.07	0.19	0.17	0.14	**0.85**	0.09		
	7	0.20	0.14	0.07	0.16	**0.83**	0.05		
	8	0.07	0.12	0.11	0.07	**0.86**	0.12		

Table 4. continued

	9	0.26	0.13	0.10	0.25	**0.74**	0.10		
Employee Responsibility	1	0.24	0.04	0.13	0.13	0.10	**0.84**		
	2	0.26	0.08	0.15	0.12	0.16	**0.85**		
	3	0.31	0.10	0.26	0.23	0.16	**0.63**		
	4	0.30	0.13	0.14	0.21	0.12	**0.60**		

Table 5. Correlations among critical factors

Factor	MGTCOM	EDTRAIN	CUSTFOC	PROMGT	QMETRIC	EMPRESP
MGTCOM	(.94)	.56	.53	.56	.42	.61
EDTRAIN		(.90)	.29	.50	.56	.36
CUSTFOC			(.80)	.53	.21	.49
PROMGT				(.91)	.57	.54
QMETRIC					(.96)	.37
EMPRESP						(.90)

All correlations are significantly different from zero (p = .05) and one (p = .05).
Diagonal values represent Cronbach's alpha.
Legend:
MGTCOM Top IS Management Commitment
EDTRAIN Education and Training
CUSTFOC Customer Focus
PROMGT Process Management
QMETRIC Quality Metrics
EMPRESP Employee Responsibility

user satisfaction is often used as a surrogate for software quality (DeLone & McLean, 1992). The performance measures chosen were:

1. Software-related quality performance of the information systems (IS) department during the past three years relative to industry standards.
2. Overall organizational quality (both software and non-software) performance during the past three years relative to industry standards.
3. Customer satisfaction with software quality during the past three years.

Each respondent was asked to rate, based on his or her perception, the three performance measures on a five-point Likert scale ranging from "very low" to "very high." The three performance measures were used to assess criterion validity. Regression analysis results revealed that the critical factors of software quality management (i.e., 36-item scale) significantly impacted each of the three performance measures, respectively: $F = 87.46$, $p < 0.0001$; $F = 52.96$, $p < 0.0001$; $F = 97.36$, $p < 0.0001$. The corresponding coefficients of determination were 38%, 27%, and 41%. As shown in Table 6, these values are at or above coefficients of determination for each of the six factors taken individually. These results indicate that the instrument has a relatively high degree of criterion validity.

Table 6. Mean, standard deviation, and R^2 for each factor

Factor	*mean*	s.d.	P1-R^2	P2-R^2	P3-R^2
MGTCOM	3.65	.892	.314	.196	.336
EDTRAIN	2.93	.954	.163	.183	.200
CUSTFOC	3.92	.645	.261	.279	.388
PROMGT	3.43	.800	.336	.239	.371
QMETRIC	2.64	.915	.159	.104	.139
EMPRESP	3.78	.807	.305	.197	.298

P#-R^2 columns contain the coefficients of determination between the factor and each of the three performance measures.

DISCUSSION

Over the years, software has become ubiquitous in reengineering business processes. From payroll systems to airline reservation systems, software plays a vital role in facilitating business processes. Given the importance of these software systems, managing their quality is essential to the success of the business processes they support. Because critical factors are important predictors of software quality performance, with a better understanding of the critical factors of software quality management in an organization, relevant factors can be manipulated to improve software quality performance. For instance, a manager wishing to improve software quality management efforts could use our instrument as follows. First, the manager could administer the 36-item scale among the firm's IS professionals. Second, based on these results, he or she could then compute the means for each of the six critical factors. Finally, the manager could use the means, standard deviations, and coefficients of determination (R^2 for performance) from our study as reported in Table 6 as an initial benchmark to compare and contrast with those values obtained from his or her firm. Furthermore, once firm-wide and industry-wide benchmarks are available, managers will be able to assess the effectiveness of software quality management practices across applications, projects, divisions, and firms.

The importance of software quality management is highlighted by the increasing number of published works on the topic. One study in particular is relevant to the issues addressed in this paper. In adapting TQM to software, Ravichandran & Rai (2000) identified a set of quality constructs and their relationships. Two key differences between their work and current study can be identified. First, we synthesized extant literature both within and outside the context of TQM to identify critical factors of software quality management. Second, those authors chose only senior IS executives as the population while we included IS professionals at various levels of the organization. IS professionals at all levels contribute to software quality, and therefore their view on quality management practices is relevant to identifying the applicable constructs. We believe that the findings in the two studies are likely affected to some extent by the differences in the sample population. For instance, results of their study suggest senior management leadership, mechanisms to promote learning, and process management as key factors differentiating high and low quality performing IS units. In comparison, results in this study suggest top IS management commitment, employee responsibility, and process management as the critical factors most contributing to software quality (see Table 6). In fact, in the current study, education and training emerged as the least indicator of software quality among the six critical factors. Given that skills are a necessary prerequisite for software quality (e.g., Arthur, 1993), it can be speculated from our findings that the acquired skills may not be fully utilized in developing quality software.

Furthermore, it can be argued that the affects of employee responsibility on software quality can only be truly assessed by IS professionals at both managerial and non-managerial levels.

Although CMM and ISO 9000 have been adopted by organizations to assess their ability to develop quality software, as discussed earlier, both frameworks pose certain limitations. One advantage of the instrument developed in this study is that it could be used to confirm (or refute) a software process capability assessment in CMM or an ISO 9000 certification. Moreover, because of costs involved in conducting CMM and ISO 9000 assessments and because of most organizations' aspiration to achieve a favorable assessment, an organization could first determine the effectiveness of its software quality management practices using our instrument. Note that the instrument developed in our study is easier, shorter, and more cost effective to implement than both CMM and ISO 9000. After making the necessary software quality improvements based on the assessment from our instrument, the organization could, if necessary or deemed useful, authorize a more expensive CMM or ISO 9000 assessment.

This study has some limitations. First, we established criterion validity by examining the coefficients of determination between the six factors and general quality performance measures. However, quality management practices may differ from one software project to another, and thereby affecting the performance of a particular software system. Hence, administering the instrument to members of a particular project team and subsequently assessing performance measures during the operation of the software system could give a better indication of the effects of software quality management practices specific to a particular software project.

Second, the use of subjective measures as surrogates for software quality performance can be problematic. As noted earlier, subjective measures were chosen due to the diversity in size and type of the firms employed in this study. It simply is not possible to have an objective, comparable measure across these firms that is readily available. However, if available, objective measures could provide a more accurate assessment of software quality performance. Possible objective measures for future research include number of defects encountered during the first month of operation and end-user satisfaction reports.

Finally, as with any other research, findings of our study should be replicated by considering any time sensitive items (software quality management factors that could change over time – e.g., management commitment). More research is required to verify and further support our findings, and the quantitative findings reported in our study could be complemented with qualitative research. Furthermore, in the context of software quality management, future research should examine techniques such as Balanced Scorecard that provides a mechanism for assessing a firm's quality management practices in terms of its overall strategies and Information Technology Infrastructure Library (ITIL) that offers a framework of best practices to facilitate the delivery of high quality IT.

SOFTWARE QUALITY MANAGEMENT IN OPEN SOURCE SOFTWARE

Open source software (OSS) development has gained tremendous popularity over the last decade (Lee et al. 2009). In OSS projects, developers from all over the world come together voluntarily to construct some software artifact. Once built, individuals and business are able use the source document free of charge through an OSS licensing agreement. As of January 2009, SourceForge, the widely accepted portal for OSS development, hosts more than 180,000 OSS projects with over 1.9 million registered users.

The instrument presented in this paper enable managers in a traditional organization to better

understand their quality management practices and consequently provide a roadmap for improving software quality performance. However, it does not fully address software quality management issues in a virtual OSS community that lacks classical hierarchical structures consisting of managers and employees, uniform development processes, and clear-cut customers. As Gurbani et al. (2006, p. 473) observe, OSS has "very little in the way of formal process," and instead insures quality by "placing control over what goes into releases in the hands of a benevolent dictator or a small group of proven technical experts." In this final section, we address software quality management issues in the emerging OSS paradigm.

While we identified process management as a critical factor of SQM, in a distributed development environment such as OSS, effective project coordination is essential for developing quality software (Aberdour, 2007). This coordination effort involves OSS project setup, member and role assignment, change request management, code submission management, and defect reporting, resolution, and prioritization. Because processes used across OSS projects vary (Koch & Neumann, 2008), project coordination becomes a critical factor for SQM to reduce variability.

The first item in our SQM instrument gauges whether the software processes are documented. However, most OSS processes are, in fact, not formally documented (Aberdour, 2007). At times, the process is established spontaneously, although OSS project managers adhere ostensibly to established norms in process management. Nonetheless, OSS projects that lacked a formal process have achieved tremendous success. Such successes are often attributed to voluntarism, project champion(s), organizational sponsorship, license choice, and self-organization (Fitzgerald 2006; Gurbani et al., 2006; Subramaniam et al., 2009; Yu, 2008). Hence, an instrument for measuring critical factors of SQM needs to account for process intricacies in OSS development.

Aberdour (2007) offers an overview of quality management differences in OSS and traditional closed-source software development. On many dimensions, OSS practice manifests contrary to critical factors of SQM identified in our instrument. For example, OSS process is neither defined nor documented; design is often overlooked for expediency; unstructured and informal testing and quality assurance methodology. Nonetheless, as Stamelos et al. (2002) revealed, OSS often generate higher quality software than comparable commercially developed software. Hence, an instrument for measuring SQM for OSS needs to account for critical factors that enable OSS projects to produce quality software. Factors such as OSS members' ownership of the software developed could prove an indicator of OSS quality.

Any attempt to develop an instrument for measuring critical factors of SQM for OSS may benefit from taking a systematic approach such as the one undertaken in this study. First, existing literature in OSS quality management must be examined to disregard constructs such as management commitment that are irrelevant in OSS and instead, identify critical factors such as members' ownership perception that are germane to OSS. Second, sample items for each critical factor need to be generated and content validity assessed. Finally, upon administering the survey, reliability and validity of the instrument need to be assessed. The resulting instrument could then be used to measure critical factors of SQM in OSS development.

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ENDNOTES

[1] It should be noted that scholars have recently started to adapt the term capability maturity model integration (CMMI) when referring to traditional CMM process improvement approach.

[2] For example, Ravichandran and Rai (2000) have an entire category (out of a total of 14 categories) titled "Formalization of Analysis and Design." They list 4 items under this category. Once example item is "Idea generation techniques such as brain storming are used in system design." Such items clearly point to a more micro-level focus taken by Ravichandran and Rai.

[3] Treating surveys that were returned undeliverable as they were never sent out is a common practice adopted by many researchers. For example, Compeau and Higgins (1995) followed a similar practice in their article that appeared in MIS Quarterly. Hence, our response rate is 152 / (957-91) = 18%.

APPENDIX

An Instrument for Measuring the Critical Factors of Software Quality Management

The initial 54 items used for measuring critical factors of software quality management.

The items noted with an asterisk (*) were subsequently deleted from the instrument.

For each item, a response on a 5-point Likert scale (1 = Strongly Disagree; 2 = Disagree; 3 = Neutral; 4 = Agree; 5 = Strongly Agree) was solicited.

Top IS Management Commitment

Top information systems (IS) management commitment to developing software.

1. Top IS management assumes responsibility for quality performance.
2. Top IS management is evaluated on quality performance.
3. Top IS management links quality to the success of the IS function.
4. Top IS management participates in quality improvement efforts.
5. Quality issues are discussed during top IS management meetings.
6. Top IS management participates in quality-related planning (e.g., quality goals, guidelines, metrics, etc.).
7. Top IS management emphasizes quality in relation to cost and schedule objectives.
8. Top IS management allocates necessary personnel resources for quality improvement.
9. Top IS management provides the leadership to create an overall quality culture.

Education and Training

Quality-related education and training for IS personnel and IS management.

1. *Specific work-skills training is provided for IS personnel.
2. Quality-related training is provided for IS personnel.
3. Quality-related training is provided for IS management.
4. Statistical techniques (e.g., control charts, variation analysis, etc.) are emphasized in quality-related educational programs.
5. Quality metrics are emphasized in quality-related educational programs.
6. Necessary non-personnel resources (e.g., financial capital) are provided for quality- related education and training.

Customer Focus

Focusing on customers who are any internal or external constituents for whom the software is developed.

1. Customer requirements are completely elicited in developing software.
2. Customer requirements are fully incorporated into the software development process.
3. Customer requirements are traced and referred back to throughout the software development process.

4. Customer requirements are maintained flexible during software development in order to handle possible changes in customer needs.
5. *Surveys are employed to assess customer satisfaction with the software.
6. *Customer feedback is incorporated into the software development process.
7. *Customers are involved throughout the software development process.

Process Management

Managing the process in developing software

1. Software processes are documented.
2. *Software processes utilized in practice are compared against ideal processes.
3. *Software processes of other organizations (e.g., competitors) are benchmarked.
4. Software processes are continuously improved.
5. *Top management emphasizes process quality in relation to product quality.
6. *Configuration Management techniques are utilized throughout the software development process.
7. Inspections and reviews are utilized in verifying various software documents (e.g., requirements specification, design specification, code, etc.).
8. A comprehensive testing program is utilized to validate the software.
9. *Statistical methods (e.g., control charts, variation analysis, etc.) are used to control the software process.
10. *Computer-Aided Software Engineering (CASE) tools are utilized in the software development process.
11. *Defect prevention is emphasized over defect detection.
12. *Software defects are thoroughly analyzed.
13. *Software reuse is emphasized.
14. Software process is emphasized over expediency.

Quality Metrics

Using quality-related metrics in developing software

1. Software quality metrics are available.
2. Software quality metrics are utilized.
3. Data regarding quality are collected.
4. Data regarding quality are analyzed.
5. Statistical techniques (e.g., control charts, variation analysis, etc.) are used in analyzing data regarding quality.
6. Quality metrics are tightly coupled with the software development process.
7. Quality metrics are valued by the IS management in improving software quality.
8. IS personnel value quality metrics in improving software quality.
9. Collecting data regarding quality is emphasized over expediency.

Employee Responsibility

Employee responsibility for developing software

1. IS personnel are held responsible for quality performance.
2. IS personnel are evaluated on quality performance.
3. IS personnel are rewarded for quality performance.
4. IS personnel link quality to the success of the IS function.
5. *IS personnel are involved in software quality improvement efforts.
6. *IS personnel participate in quality-related planning (e.g., quality goals, guidelines, metrics, etc.).
7. *Quality teams are implemented in the IS department.
8. *IS personnel emphasize quality in relation to schedule objectives.
9. *IS personnel provide feedback on quality to IS management.

Chapter 13
Is "Usefulness" or "Use" the Superior Metric When Assessing Web-Based Information System Success?

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ABSTRACT

Managers are increasingly confronting the question of how to convey electronic information to e-commerce users in a manner that permits individuals to resolve information search related problems more easily. Information service quality and the associated performance outcomes are challenging to manage during Web-based interactions, primarily because such settings involve several features (i.e., less tangible contact, more uncertainty, differing feedback loops between business and consumers) not found in more traditional exchanges. To capture a broader view of the quality of information offerings in ecommerce settings, the model tested in this study compares the DeLone and McLean (2003) framework, one that includes use as an outcome measure, with a model suggested by Landrum and Prybutok (2004), one that features usefulness as its outcome measure. A random sample of Army Corp of Engineers library customers was performed at two library sites with the Corps. Theoretical and applied implications are developed and discussed.

DOI: 10.4018/978-1-60566-962-5.ch013

INTRODUCTION

A major objective of Web-based environments is to deliver required information in a timely fashion to Web-linked constituents. Both information overload and selective attention are commonly associated with Web-based interactions (Berthon et al. 1999). Prudent selection of information and high quality presentation of that informatin is important to creating a competitive web site because web-based consumers do not or cannot devote the time necessary to process all available information. In addition, organizations are only beginning to address individual preferences and the associated perceptions of the Web environment (Beatty, Shim, & Jones 2001; Zviran 2008). Consequently, insight is needed into the factors that create situations where problematic information system interactions are likely (Liu et al. 1997; Tang 2007). For practical and theoretical reasons alike it is important to conceptualize the processes and procedures associated with **Web-based information service**. An information service based conceptualization permits drawing useful distinctions between different levels of information service (Barnes & Vidgen 2001). **Information service quality (ISQ)** is relevant to those distinctions and is defined as how well the information provided meets or exceeds the user's expectations (Barnes & Vidgen 2001; Miller, et. al. 2008; Pitt et al. 1997).

While several variables that affect **information system success** have been identified (DeLone & McLean 1992), the role that **information service** plays in the success of information systems has not been widely investigated. Numerous researchers contend that **ISQ** and the associated information service performance is an important factor that affects the success of information systems (Rands 1992; Ferguson & Zawacki 1993). However, the nature of that role is not clearly understood. Although numerous studies examine **IS success factors**, few studies incorporate **service quality** into an IS success model. In addition, although Rai et al. (2002) compare DeLone and McLean's (1992) model with Seddon's (1997) model, these two models do not consider service quality as one of the success factors in the model. Because **service quality** is becoming increasingly important in the IT industry, this study was designed to address the impact of service quality impact on two IS success models and contribute to the literature in the following ways. First, it examines the effects of service quality in IS success models. Second, the study empirically validates DeLone and McLean's (2003) model. Third, it compares and contrasts DeLone and McLean's (2003) the model developed by Landrum and Prybutok's (2004). Finally, the study assesses the effect of an objective measure – **"use"** versus subjective **"usefulness"** in IS success models - by examining the predictive validity of various independent variables on use versus usefulness.

Consistent with this conceptual foundation, the following research questions are addressed in this paper:

- What is the identity of the factors that influence the relationship between **information service** and **information systems success** in Web-based interactions?
- Is **"usefulness"** or **"use"** the better construct when measuring information success?

RESEARCH MODEL

The most popular instrument available to measure service quality is **SERVQUAL** (Parasuraman et al. 1988). SERVQUAL was designed as a generic measure of service quality and is applied in a variety of organizations and research settings. It has been used to measure service quality in information service industries (Pitt et al. 1997; Coleman et al. 1997; Boudreau et al. 1997).

Web-based information systems are defined as information systems that require the usage

of the World Wide Web and include services related to the delivery of information, such as papers, reports, books, etc. Web-based library service offerings provide information services to customers, and therefore such offerings are appropriately examined using tools to measure service quality (Zeithaml et al. 2002). Because these offerings are often provided through on-line databases linked to back office systems, information systems function as the platform on which information services operate. Thus, **information systems** success is an important component for understanding factors that influence the quality of information service offerings.

In 2004, Landrum and Prybutok used multiple regression to test an IS success model with service quality as one of the independent variables. In that work usefulness and satisfaction were used as independent variables and the two different models that resulted were compared. Although reasonable values of R^2 were obtained for two models with usefulness and satisfaction have R^2 values of 57% and 65% respectively, a model fit was not performed. To better compare the different models, we are now testing their model via Structural Equation Modeling (SEM) and comparing two different models – **"usefulness"** as originally proposed and **"use"** because it is an actual measure rather than a perceptual measure. Comparing these models allows us to better understand the models as well as the relationship between **information systems service** and other variables posited to influence **information system success** during Web-based interactions.

Information Service Measure

SERVQUAL proposes that service quality can be assessed as a gap between what customers expect and the performance they perceive to have actually received (Parasuraman et al. 1988). Respondents rate their expectations of service from an excellent organization, and then rate the performance they perceive to have received from a specific organization. Service quality is calculated as the difference in the two scores.

Cook and Thompson (2000) investigated the reliability and validity of SERVQUAL instrument in a library service context. In their application, SERVQUAL displayed three dimensions rather than the five dimensions originally proposed by Parasuraman et al. (1988). They concluded that the responsiveness, empathy and assurance dimensions overlapped in this particular service domain. Nitecki and Hernon (2000) adapted SERVQUAL to the library at Yale University and found that among the five dimensions of SERVQUAL, respondents thought reliability was most important and empathy least important among the quality dimension. Cullen (2001) suggested the SERVQUAL model is appropriate for evaluating electronic service delivery and exploring relationships between service quality and satisfaction at macro or micro levels.

Although SERVQUAL is widely used, researchers have identified several concerns with its ability to measure the gap between practical and ideal levels of service quality (Babakus & Boller 1992; Brown et al. 1992; Van Dyke et al. 1997; Van Dyke et al. 1999). Some researchers, including the original instrument developers, suggest performance scores alone exhibit better reliability and validity than difference scores (Babakus & Boller 1992; Cronin & Taylor 1992; Parasuraman et al. 1994) That is because the variety of ways in which consumer expectations are interpreted often further muddle the evaluative process (Landrum & Prybutok 2004; Teas 1993).

These issues are even less well-understood in Web-based environments than they are in traditional marketing environments (Barnes & Vidgen 2001; Pitt et al. 1997; Teas 1994). Given the concerns about the use of the gap score in the literature and the demonstrated superiority of performance only scores when examining the relevance of the service quality to success (Landrum & Prybutok 2004), it appears appropriate to use the performance measures for developing

a model of the relationships among ISQ and success measures. The performance-only scores constitute the SERVPERF instrument and were used in this study.

The primary research question to be addressed pertains to the extant relationship between **ISQ** and the success of the information system delivering the information. For that reason, our model assesses Web-based library information system success, and the role of ISQ in such a system's success. An important contribution of this study is the understanding it helps provide about users' perceptions of the relationships between perceived service quality performance and perceived **information system success.**

Information System Success

The model of information system success employed in this study is grounded in and guided by the classic DeLone and McLean (1992) framework. This framework posits that **information system success** is a function of the interaction among six major variables: **system quality**, information quality, **use**, user satisfaction, individual impact, and organizational impact. **System quality** refers to the perceived ease of use of a system. Information quality refers to the perceived quality of attributes of information, such as accuracy, relevancy, precision, reliability, completeness, and currency. This differs from ISQ because **information services quality** addresses user expectations of the information provided. Use is defined as the number of times a user (i.e., customer) requests or utilizes a service. **User satisfaction** is "the sum of one's feelings or attitudes toward a variety of factors affecting that situation" (Bailey & Pearson 1983, p. 531).

DeLone and McLean's framework was applied and its measurement properties addressed in a number of ways (Seddon & Kiew 1994; Seddon 1997). Because the way in which outcomes (i.e., managerial decisions made) impact consumer or organizations are not being measured, the remaining two variables (i.e., individual impact and organizational impact), were considered outside the scope of this study. Neither variable is included in our model.

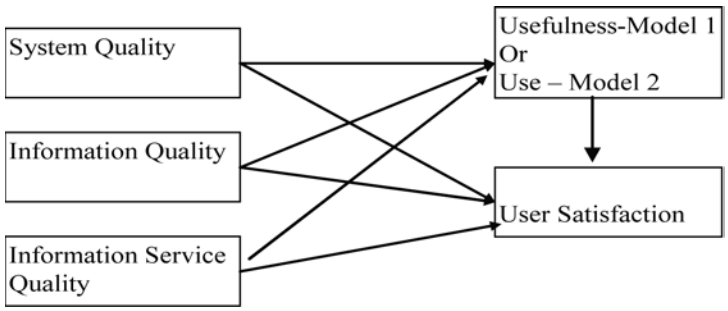
Seddon and Kiew (1994) substituted **"usefulness"** for **"use"** in the DeLone and McLean model. In doing so, they suggested "use" only relates to satisfaction when use is voluntary, and that in many instances this is not the case. In Seddon and Kiew's model, usefulness affects satisfaction, but the relationship is not reciprocal. We adopt this substitution in the current model because, although customers have a choice about whether to purchase from an on-line company, once they make the decision to do so, they have little choice about using the web interface the firm provides.

Pitt, Watson, and Kavan (1995) believe **service quality** is a critical element in **information system success** and proposed that service quality be included as one of the dimensions that affect use and user satisfaction in the DeLone and McLean model. DeLone and McLean (2003) updated their model in 2003 to include service quality. In the updated DeLone and McLean model, service quality, system quality and information quality influence use and **user satisfaction**. User satisfaction is a widely used surrogate for information systems success (1988). In some situations, satisfaction is thought to be a better surrogate for success than actual use (Jones & Beatty 2001; Ives et al. 1983).

Although Delone and Mclean (2003) acknowledge the need for inclusion of service quality as a separate construct in their model, they also state that the measurement of this construct requires further substantiation. We believe this represents one important contribution of this study because in it we show that service quality construct in relation to IS success. Because Web-based offerings are largely service based, we include service quality in our model as well.

The model of **Web-based information system success** posited here suggests **service quality**, **information quality**, and **system quality** all af-

Figure 1. Model of information system success with Model 1 with usefulness and Model 2 with use



fect usefulness and user satisfaction. A diagram of the proposed model of information system success that incorporates ISQ is shown in Figure 1. Because ISQ is proposed to affect information system success in Web-based library information service interactions, we examined the model in light of the proposition below.

This work proposes a model (Figure 1) that allows examination of these relationships. Via paths depicted in the model we also examine the seven specific alternative research hypotheses. These are shown below:

H1: System quality is positively correlated with usefulness.
H2: Information quality is positively correlated with usefulness.
H3: Information service quality is positively correlated with usefulness.
H4: System quality is positively correlated with user satisfaction.
H5: Information quality is positively correlated with user satisfaction.
H6: Information service quality is positively correlated with user satisfaction.
H7: Usefulness is positively correlated with user satisfaction.

METHODOLOGY

A random survey of Army Corps of Engineers library customers was performed at two library sites within the Corps. This sampling frame tapped into one type of Web-based library information service setting: on-line library-customer relationships. Customers use the system to locate items in the library, to obtain materials on-line without visiting the library, to access information about library services, operating hours, and special programs, and to request assistance from library staff. This setting allows us to examine the quality of information services provided and the success of the information system that library customers use to access those services.

Findings from this setting should be relevant to select B2C settings because customers are increasingly using organizational web sites to find information about organizations and what they offer, and to locate products and services. Obtaining electronic library services is similar to the services that a consumer might obtain via other electronic service providers such as an online discount broker. For example, when an investor selects Charles Schwab, Fidelity or another broker they have available a variety of electronic information services for the purpose of investigating stocks or mutual funds. These services are provided as an internal service for clients. Changing the information service provided by an online broker requires transferring an account to a different broker and such a change has significant obstacles. While changing brokers is not as onerous as needing to change jobs to change the electronic services available

via a company's internal electronic library there is a parallel in that one must make considerable effort to change the information services the broker provides.

The two libraries in this study have similar missions and similar types of customers. The main difference between the two sites is size. Customers were chosen randomly from a list of users at the smaller site and from a database of users at the larger site. Paper questionnaires were distributed through local distribution at each site, and respondents were asked to return the unsigned questionnaire in a sealed envelope.

While use of a Web-based survey represented a sampling option for this study, we chose to distribute the survey to users who physically visited the library. This was done to permit certain service quality dimensions related to those individuals' interactions with service personnel to be assessed more accurately. This sampling frame consisted of all library users. Quite likely, these users varied greatly in their experience with computers, the Internet and Web surveys.

According to Morrel-Samuels (2003), paper surveys and web surveys tend to attract different types of respondents. In general, web survey users are more computer literate than paper survey users. In addition, the response rates for web based surveys are potentially much lower than those for paper surveys (Morrel-Samuels, 2003). The prospect that a significant drop-off between the click-through rate and response rate may arise is also in play (Porter and Whitcomb, 2003).

This last problem was avoided because many users completed the survey during their visit to the library. Furthermore, there may be normative and cognitive factors that account for response differences between paper and Internet Survey (Dillman 2000). Hayek et al. (2003) conclude that a web survey generates more favorable responses than paper based surveys. At the time this data was collected, these issues appeared sufficiently important to justify use of a traditional paper survey method.

The 1994 version of the SERVPERF portion of SERVQUAL was modified for use in this study. All 21 items used in the 1994 version were preserved, with minimal changes of the wording of each item to apply to a library web setting. The items in the first section of the instrument matched the dimensions proposed by Parasuraman, Zeithaml, and Berry (1994).

The next section contained items to measure **information quality** and **system quality**. Items such as "relevance," "accuracy," "precision", "reliability", "currency", and "completeness" of *information received* measured information quality. System quality was measured with items such as "easy to use," "easy to learn," "easy to become skillful at using", and "can interact with the system in a clear and understandable way."

The third section contained items to measure **usefulness** and **user satisfaction**. Usefulness was measured with items such as "enhances my effectiveness", "accomplish task faster", "improve ability to do research", "be more productive", "useful", and "enables me to be more productive." User satisfaction was measured on the adequacy which the system met information needs, system effectiveness, system efficiency, and user satisfaction with the system as a whole. **Use** was measured with the number of times a person has used the library's online catalog. To make measurement comparable among all constructs, use was scaled into five categories: 1=none, 2=once, 3=2 to 5 times, 4=6 to 10 times, 5=11 or more times.

Table 1 summarizes the survey instrument. Respondents were asked to rate perceived performance of each of the original SERVPERF items (section 1 of our instrument) on a seven-point scale ranging from low to high. For scale compatibility and to avoid analytical complications, the same seven-point scale was used to rate all other items in the study.

Table 1. Summary of survey instrument

Survey section	Dimension/Variable	Number of Items	Construct
Section 1	Tangibles	5	Dimension of ISQ
	Reliability	5	Dimension of ISQ
	Responsiveness	3	Dimension of ISQ
	Assurance	4	Dimension of ISQ
	Empathy	4	Dimension of ISQ
Section 2	User Satisfaction	4	Surrogate of system success
Model 1	Usefulness	6	Surrogate of system success
Model 2	Use	1	System success measure
Section 3	System Quality	4	Other influences on system success
	Information Quality	6	Other influences on system success

RESULTS

Profile of Respondents

A total of 385 useable responses were received resulting in a 37% response rate. More than 70% of the respondents were men. About 68% of the respondents were engineers or scientists. More than 75% had used the **information system** more than six times. At least 77% indicated they relied on the library staff frequently when using the library. This group featured on-line requests as well as in-person visits to the library. These percentages closely reflect the demographics of the sites studied, suggesting this sample was well qualified to evaluate **information system service quality** at their firms..

Reliability and Validity Assessment

The reliability and validity of SERVPERF as well as our measures are demonstrated in prior work (Landrum and Prybutok 2004). But in this study, the instrument is being used in a new context. Moreover, new items were added. It is therefore appropriate and necessary to examine the reliability and validity of each of our sets of measures.

All items used to measure these constructs were grounded in literature and modified as required to fit this study's context. Experts were interviewed about the inclusion of these items. Our experts included a group of information specialists within the Army Corps of Engineers and two well-known professors who have extensive academic and consulting experience in quality control and technology management.

We performed a pilot study using a small group of engineers and scientists from the Army Corps of Engineers who were not included in the group used in the final study. These engineers and scientists had similar job classifications to those used in the study and were well qualified to represent the larger group.

In addition to content validity we assessed construct validity and reliability (Nunnally 1994). Although the sets of items used to measure each of the constructs in this study are grounded in theory, they are derived from a variety of sources and some items are modified from their original scales to fit the B2C context in this study. Thus, individual measurement properties, such as dimensionality and internal consistency, may have changed in this context. Dimensionality and internal consistency are two major aspects of construct validity (Beatty et al. 2001; Nunnally 1994). Dimensionality was

Table 2. Reliability and description statistics of information system success measures

Dimension	Cronbach's alpha	Mean	Standard Deviation
ISQ	0.96	5.75	0.88
ISQ Tangibles Items	0.84	5.03	1.04
ISQ Reliability Items	0.91	5.93	0.95
ISQ Responsiveness Items	0.88	6.18	0.94
ISQ Assurance Items	0.87	5.96	0.93
ISQ Empathy Items	0.92	5.95	1.00
Information Quality	0.95	6.02	0.90
System Quality	0.98	5.28	1.40
Usefulness	0.96	5.38	1.19
Satisfaction	0.95	5.66	1.16

Note: The SERVPERF performance scores were used for ISQ dimensions

assessed using factor analysis. Internal consistency was assessed using Cronbach's alpha.

A principal factor analysis, employing Varimax rotation, was used. Eigenvalues, percent of variance explained, and factor loadings were used to assess dimensionality of the factor and the appropriateness of the indicator (Hair et al. 1998). All items loaded with a factor score of at least a 0.4 on the theorized factor (dimension). A few items showed cross loadings. But all items were retained based on the theoretical grounding of these items and their associated scales.

Cronbach's alpha was used to assess the internal consistency of the factors identified from the literature and confirmed with the factor analysis. We used the criteria that constructs with alpha of at least 0.80 are internally consistent (Nunnally 1994). The mean, standard deviation, and Cronbach's alpha for each of the factors retained are provided in Table 2. The ISQ score consists of the SERVPERF items taken as a whole in order to compare success measures. However, because conventional **SERVQUAL** practice is to show five dimensions we show the SERVPERF performance items listed by the traditional SERVQUAL dimensions as the next five factors. The alpha values for each set of items exceeded the 0.70 value recommended by Nunnally (1994).

To further assess the validity of these measures, correlations between each success measure and an overall rating of library satisfaction were examined (Table 3). The overall rating was measured using an average of four items on a 7-point scale that asked about different aspects of satisfaction

Table 3. Correlations between success measures and library satisfaction

	IQ	SQ	USEFUL	LIBSAT	SERVQ	Use
IQ	1					
SQ	0.60	1				
USEFUL	0.64	0.48	1			
LIBSAT	0.64	0.51	0.64	1		
SERVQ	0.70	0.51	0.74	0.65	1	
Use	0.11	0.07	0.16	0.08	0.20	1

Table 4. Loadings of IS success factors

	Usefulness	IQ	SQ	Satisfaction
IQ1	0.22	**0.86**	0.18	0.08
IQ2	0.25	**0.81**	0.28	0.22
IQ3	0.29	**0.83**	0.22	0.22
IQ4	0.31	**0.70**	0.31	0.27
IQ5	0.34	**0.64**	0.24	0.36
IQ6	0.30	**0.67**	0.25	0.30
SQ1	0.18	0.27	**0.88**	0.21
SQ2	0.24	0.25	**0.89**	0.21
SQ3	0.19	0.25	**0.89**	0.22
SQ4	0.25	0.25	**0.87**	0.23
Useful1	**0.80**	0.32	0.22	0.22
Useful2	**0.82**	0.22	0.24	0.26
Useful3	**0.84**	0.29	0.20	0.26
Useful4	**0.83**	0.29	0.20	0.25
Useful5	**0.79**	0.27	0.17	0.34
Useful6	**0.69**	0.33	0.19	0.39
Satisfaction1	0.39	0.25	0.30	**0.77**
Satisfaction2	0.38	0.31	0.26	**0.76**
Satisfaction3	0.33	0.32	0.28	**0.70**
Satisfaction4	0.35	0.27	0.29	**0.80**

with the library, such as adequacy, effectiveness, efficiency, and satisfaction as a whole. The 7-point scale was used because of its consistency with SERVPERF administration in prior studies. The correlations are relatively strong, and significant at $\alpha = 0.05$.

Table 4 shows the factor loadings for information quality, system quality, usefulness and satisfaction. There are no cross loadings in Table 4. Table 5 shows the factor loadings for service quality and three items cross loaded in Table 5. Tangible 5 is loaded on the tangible and reliability dimensions; Reliability 5 is loaded on the reliability and responsive dimensions; and Empathy 4 is loaded on the empathy and assurance dimensions. These cross loadings suggest these three items were perceived as similar by respondents. This was not unexpected. Prior work suggests the SERVQUAL instrument exhibits unstable dimensions in different settings (Johns et al. 2004).

Model of Information System Success

To address the relationship between **ISQ** and **information system success**, the role of service quality was examined using structural equation modeling (second order factor analysis) in AMOS. The range of squared multiple correlations (SMCs) for the loadings of individual items on each of the variables of interest and the standardized regression path coefficients for the relationships between the exogenous and endogenous variables are shown in Figure 2 and Figure 3.

The SMCs are reasonably high (using a rule of thumb of approximately 0.70) (Hair et al. 1998)

Table 5. Service quality loadings

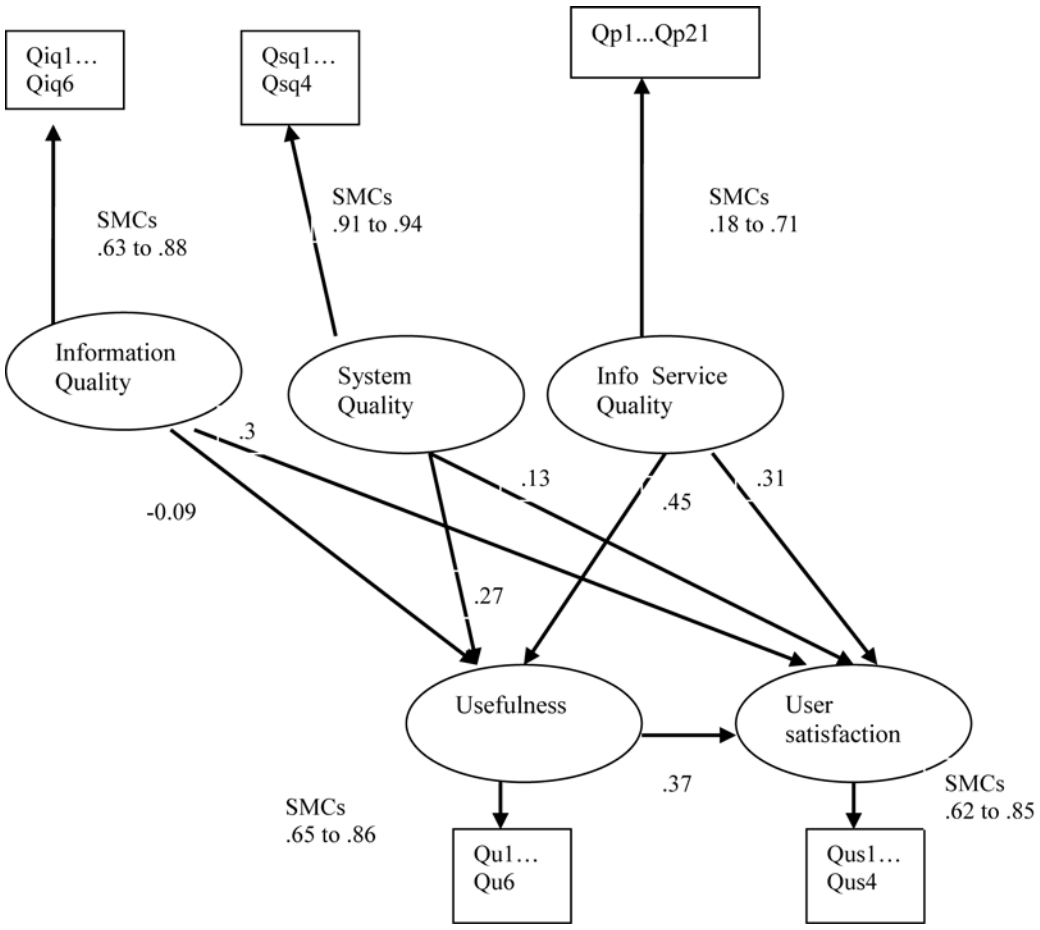
	Empathy	Reliability	Tangible	Assurance	Responsive
Tangible1	0.26	0.19	**0.74**	0.17	-0.05
Tangible2	0.05	0.16	**0.85**	0.07	0.23
Tangible3	0.39	0.20	**0.53**	0.15	**0.57**
Tangible4	0.22	0.09	**0.70**	0.19	0.38
Tangible5	0.16	**0.50**	**0.59**	0.18	-0.16
Reliability1	0.32	**0.66**	0.26	0.32	0.01
Reliability2	0.35	**0.68**	0.18	0.35	0.17
Reliability3	0.33	**0.77**	0.23	0.21	0.13
Reliability4	0.37	**0.79**	0.18	0.21	0.17
Reliability5	0.21	**0.52**	0.11	0.35	**0.59**
Responsive1	0.34	0.24	0.20	0.14	**0.73**
Responsive2	0.12	0.37	0.12	0.08	**0.78**
Responsive3	0.16	0.49	0.13	0.20	**0.69**
Assurance1	0.17	0.29	0.20	0.17	**0.77**
Assurance2	0.34	0.35	0.23	**0.62**	0.20
Assurance3	0.38	0.28	0.22	**0.76**	0.19
Assurance4	0.36	0.35	0.26	**0.55**	-0.05
Empathy1	**0.74**	0.21	0.22	0.34	0.09
Empathy2	**0.66**	0.36	0.14	0.39	0.16
Empathy3	**0.69**	0.24	0.20	0.39	0.19
Empathy4	**0.52**	0.38	0.20	**0.59**	0.13

for each of the items except for items pertaining to the tangibles dimension of the service quality construct. However, decisions to eliminate items in confirmatory factor analysis are based on theoretical as well as statistical considerations. Jöreskog and Sorbom (1989) suggest that if substantive theory indicates that a particular parameter be included in the model, it is better to retain it even though it is not statistically significant. Because theory indicates that these are substantive measures in the **SERVPERF** model, and because each of the dimensions they represent exhibit ample reliability, these items were retained.

The path model was examined using standard criteria commonly used to compare model specifications. These are measures of absolute fit, incremental fit, and parsimonious fit (Bollen 1989; Hair et al. 1998). Measures of absolute fit provide information about how well the proposed model predicts the observed correlations. A commonly used measure of absolute fit is the Chi-square (χ^2) statistic (Carmines & McIver 1981). However, the χ^2 is sensitive to sample size where sample size is greater than 200 (Hair et al. 1998; Loehlin 1992). The sample size in this study is 385, and the calculated value for χ^2 has a $p = .0000$. Therefore, we rely on the incremental fit and parsimonious fit indices to assess the strength of the model.

Measures of incremental fit compare the proposed model to the null model, and the parsimonious fit indices are used to determine whether the overall model fit has been achieved by over fitting the data (Hair et al. 1998). Incremental fit indices provided by AMOS include the Normed Fit Index

Figure 2. Results of information system success model performance with usefulness



(NFI), Tucker Lewis Index (TLI), Comparative Fit Index (CFI), Incremental Fit Index (IFI), and the Relative Fit Index (RFI). The parsimonious fit indices include the Parsimonious Normed Fit Index (PNFI) and the Parsimonious Comparative Fit Index (PCFI). These indices (Zeithaml et a. 2002; Hair et al. 1998; Bentler 1990; Bentler & Bonett 1980; Bollen 1986) for the model are shown in Table 6. All the fit indices shown in Table 6 are greater than 0.9. The results suggest that use and usefulness perform equally well in DeLone and McLean's model and in Landrum and Prybutok's model.

The proposition tested is whether **service quality** is a stronger indicator of **usefulness** and **user satisfaction** than the traditional indicators of **information quality**, and **system quality**. This proposition is supported. The findings show that service quality is a stronger predictor of usefulness in the model (Table 7).

DISCUSSION

Service quality is positively correlated with both **usefulness** and user **satisfaction**, as shown in Table 7. **Information quality** is also positively correlated with both usefulness and user satisfaction, and usefulness is positively correlated with user satisfaction. System quality is positively correlated with usefulness and satisfaction. These findings indicate support for all the hypotheses in Model 1.

Figure 3. Results of information system success model performance with use

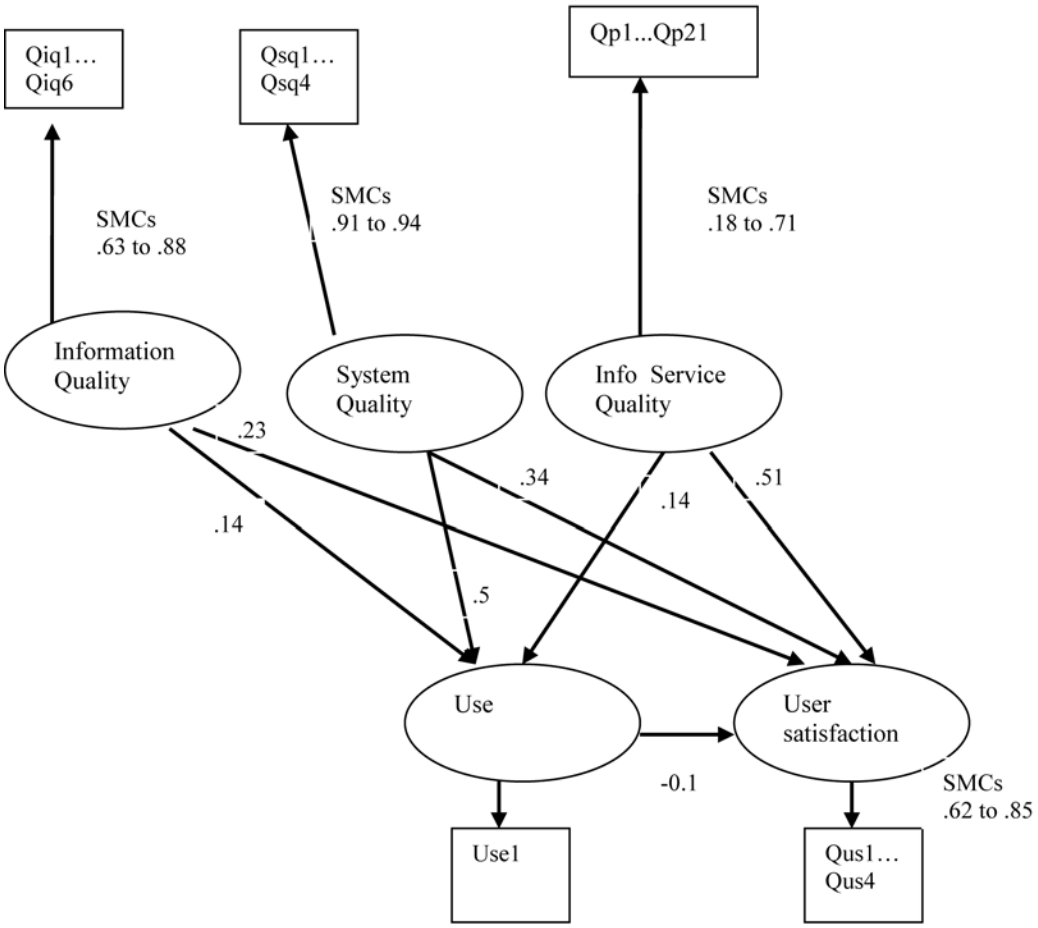


*Table 6. Incremental and parsimonious fit indices for each of the models**

Index	Criteria*	Information System Success Model with Usefulness	Information System Success Model with Use
NFI	≥ .90	0.95	0.95
TLI	≥ .90	0.96	0.96
CFI	≥ .90	0.96	0.96
IFI	≥ .90	0.96	0.96
RFI	≥ .90	0.95	0.95
PNFI	Higher is better	0.85	0.84
PCFI	Higher is better	0.86	0.85

* Based on AMOS User's Guide, 1997; Bentler, 1990; Bentler and Bonett, 1980; Bollen, 1986; Bollen, 1989, Hair, et al., 1998

Table 7. Path coefficients for usefulness and user satisfaction in model 1

Predictor	Usefulness	User Satisfaction
Information Quality	0.15	0.33
System Quality	0.29	0.14
ISQ	0.46	0.37
Usefulness	n/a	0.35

Table 7 shows that the coefficients for the paths from information quality, system quality, and ISQ to usefulness are 0.15, 0.29, and 0.46, respectively. The data suggests ISQ weights most heavily in predicting usefulness. The coefficients for the paths from information quality, system quality, ISQ, usefulness to satisfaction are 0.33, 0.14, 0.37, and 0.35, respectively. By comparing the weights of the coefficients, our data shows that ISQ is most important in predicting satisfaction followed by usefulness and information quality.

Table 8 shows that the path coefficients from information quality, system quality, and ISQ to use are -0.09, 0.5, and -0.14, respectively. The data suggest that system quality weights most heavily in predicting use. However, information quality and ISQ is negative related with use. The path coefficients from information quality, system quality, ISQ, use to satisfaction are 0.3, 0.34, 0.51, and -0.1, respectively. By comparing the weights of the coefficients, our data shows that ISQ weights most heavily in predicting satisfaction. However, use is negatively related with satisfaction.

Table 9 and Table 10 below show each of our hypotheses and the associated significance for those hypotheses. Our structural analysis on both models supports the model fit. When usefulness is used in the model, all path coefficients are significant at 0.01 level, as shown in table 9. When use is used in the model, all path coefficients except one are significant at the 0.01 level. The exception involves the path from information quality to use is significant at 0.05 level. This is shown in Table 10.

DIRECTIONS FOR FUTURE RESEARCH AND CONCLUSIONS

The literature provides two versions of evaluating **information systems success**. DeLone and McLean (2003) suggested **use** whereas Seddon and Kiew (1994) suggested **usefulness**. In this study we empirically examine the difference between these two models using data collected from an army library. We contribute to the literature by validating the two models with ISQ included which is not present in prior IS success model studies. Our analysis suggests the model with use performs every bit as well as the model with usefulness. These results support the contention that both models are adequate for information service delivery.

Table 8. Path coefficients for use and user satisfaction in model 2

Predictor	Use	User Satisfaction
Information Quality	-0.09	0.30
System Quality	0.50	0.34
ISQ	-0.14	0.51
Use	n/a	-0.1

Table 9. Hypotheses Tests based on the t value and Significance of the Path Coefficients in Model 1

Hypothesis	Supported	t value*	p value
H1:System quality is positively correlated with usefulness	Supported	5.27	0.00
H2:Information quality is positively correlated with usefulness	Supported	3.12	0.00
H3:ISQ is positively correlated with usefulness	Supported	9.12	0.00
H4:System quality is positively correlated with user satisfaction	Supported	3.81	0.00
H5:Information quality is positively correlated with user satisfaction	Supported	6.25	0.00
H6:ISQ is positively correlated with user satisfaction	Supported	7.46	0.00
H7:Usefulness is positively correlated with user satisfaction	Supported	6.73	0.00

* Critical ratio (C.R.) in AMOS output.

We observed difference in the signs and values of the regressions coefficients when using use versus usefulness as independent variables in the models for predicting usefulness and satisfaction. It is possible that some of these differences are related to the fact that usefulness is a subjective, perceptual measure but use is an objective measure. For example, in the use model, some negative coefficients are produced. One plausible explanation is that negative experiences with the use of the library system may cause the users to have negative evaluations about the information service quality.

Managers of Web based offerings must go a step beyond high quality information and determine what their potential customers/users expect the site to provide in terms of other factors. These factors include expectations about the company's responsiveness, its willingness to help, the knowledge and courtesy of the company's staff on help-lines, and how personal the user feels about the attention that was received. Managing these factors in a web environment is challenging, but probably necessary in order to provide Web-based offerings that customers find useful. This is further supported by the findings about the relationship between ISQ and user satisfaction. Regardless of the quality of the offering, poor ISQ results in a dis-satisfied customer.

This study provides a model that establishes the importance of the relationship between ISQ and information system success in a Web based electronic library environment. This effort contributes to the body of knowledge in that it supports the theoretical and practical significance of the relationship between **ISQ** and **information system success.**

Table 10. Hypotheses tests based on the t value and significance of the path coefficients in model 2

Hypothesis	Supported	t value*	P value
H1:System quality is positively correlated with usefulness	Supported	4.1	0.00
H2:Information quality is positively correlated with usefulness	Supported	-1.66	0.05
H3:ISQ is positively correlated with usefulness	Supported	-2.46	0.01
H4:System quality is positively correlated with user satisfaction	Supported	5.68	0.00
H5:Information quality is positively correlated with user satisfaction	Supported	6.51	0.00
H6:ISQ is positively correlated with user satisfaction	Supported	10.64	0.00
H7:Use is positively correlated with user satisfaction	Supported	-1.88	0.03

* Critical ratio (C.R.) in AMOS output.

LIMITATIONS

The relationships found in this work suggest several directions for future work. One such direction might involve the development of a single instrument that measures both ISQ and success in Web-based information service environments. In addition, because this work was conducted in one type of service setting, the generalizability of its findings is potentially limited. Factors such as industry, type of product/service offered, and customer characteristics may impact the degree to which ISQ determines usefulness and user satisfaction. Although there are instruments that measure the quality of web based offerings [see for example, Zeithaml, Parasuraman, & Malhotra (2002)], these are more generic and assume a level of invariability across these factors. Thus, research is needed that focuses on a more detailed model of what constitutes ISQ in the Web based environment.

Information service provided in a research library is similar to service delivery in academic institutes. Our findings are applicable to information service delivery in library settings. Information service delivery is usually free for employees. In many B2C settings, people have to pay for information services. The prospect that some information users may be more demanding when involved in a fee for service appears realistic. In addition, it is appropriate to test the transfer of this model to web sites that specialize in direct consumer marketing.

This study is also limited by the size of the population studied and the extent to which findings may be generalized to a wider segment of the business community. The attitudes of engineers and scientists may differ from other professions. This possibility should be analyzed using other sample frames.

Despite these limitations, the model developed here provides a foundation upon which future research in this area can be built. In addition, it provides insights into the management of Web-based offerings that suggests that usefulness and satisfaction are strongly tied to aspects related to customer perceptions of a site's performance. Managers who are able to manage these processes successfully should be able to develop web based service sites that provide their companies with competitive advantages that would prove difficult for competitors to imitate.

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Chapter 14
Identification of Critical Success Factors (CSF) and their Relative Importance for Web-Based Information Systems Development

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ABSTRACT

Today, a majority of information systems are being developed for Web environments. It is critical to understand the unique characteristics of Web-based information systems. The main objective of this study is to identify the relative importance of factors related to the development of Web-based information systems. To accomplish this, critical success factors (CSFs) for the development of Web-based applications were identified from the literature, and organized into two main dimensions and sub-dimensions. The relative importance of the dimensions was assessed through an analytical hierarchy process (AHP) method. Data were obtained in Korea from 33 experienced IT professionals representing six organizations from three different industry sectors. Respondents provided information about the relative importance of dimensions in pair-wise comparisons. As a result of the AHP analysis, information properties were found to be more important than risk control. Within information properties dimension, integrity of information was found to be the most important sub-dimension. The authors' analysis also revealed that there is an industry effect on the relative importance of the dimensions. The results appeared to be reasonable for each industry sector given its business characteristics and nature of customer interactions, contingent on industry sectors. Based on these results, a series of research questions are suggested for future studies.

DOI: 10.4018/978-1-60566-962-5.ch014

INTRODUCTION

Since 1990s, a majority of information systems are being developed in Web or Internet environments. The popularity and ubiquity of Web-based systems (Murugesan, Deshpande, Hansen, & Ginige, 2001) may be attributed to their advantages, such as user friendliness, convenience of access, and ease of administration. As a result, processes, methods, and techniques for information systems development are being dramatically transformed to suit Web-based systems (Davies, 2000; Howcroft & Carrol, 2000). These trends are well reflected in some buzz words in the current literature such as *Web engineering* (Escalona & Aragon, 2008), *requirements engineering for hypermedia and multi-media information systems* (Barry & Lang, 2001), *requirements engineering for Web applications* (Escalona & Koch, 2004), and *Web requirements* (Escalona & Aragon, 2008), which are a part of the Web-based information systems development milieu.

The extensive use of Web-based information systems has posed new challenges to researchers and practitioners, since traditional methodologies may be a poor fit for Web-based systems (Norton, 2001). Especially, in practice, the understanding of specific requirements for Web-based systems development is weak, and methodologies for Web-based applications are often ignored (Barry & Lang, 2001). On this issue, Murugesan and Ginige (2005) have observed that, "most Web application development still continues to be ad hoc, chaotic, failure prone and unsatisfactory" (p.2). These problems may be further magnified due to time pressures, whether the development is undertaken internally or externally through a vendor.

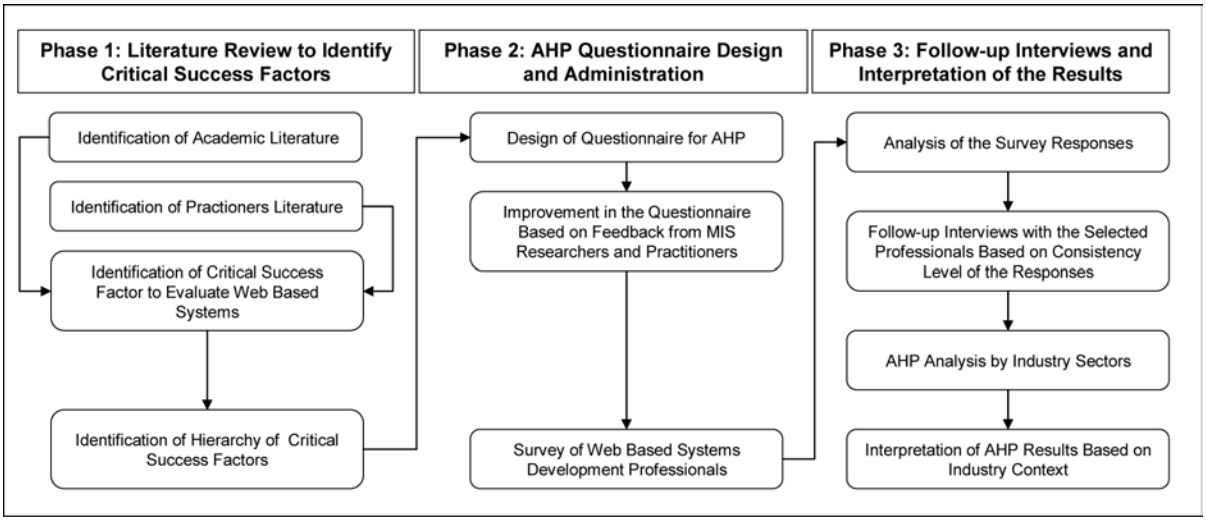
In response to these challenges, a group of researchers (e.g., Retschitzegger & Schwinger, 2000; Barry & Lang, 2001; Escalona, Torres, Mejias, Gutierrez, & Villadiego, 2007; Escalona & Aragon, 2008) have identified important gaps between the development of traditional and Web-based information systems. Further, another group of researchers (e.g., Jiang & Klein, 2001; Hartman & Ashrafi, 2002) have investigated critical success factors for information system development projects in the Web environment. These efforts dealt mainly with managerial issues such as risk, cost, and time management in successful project management, rather than issues related to understanding Web-based systems development methodologies and/or software engineering. In other words, the following two questions are not clearly examined: 1) *what are the unique critical success factors (CSFs) that should be considered for Web-based information systems methodologies?* and 2) *what is the relative importance of these CSFs for Web-based information systems development methodologies?*

Based on these research questions, this article aims to identify the unique critical success factors (CSFs) for Web-based systems development efforts through a review and synthesis of the current academic and practitioner research. The relative importance of the identified CFSs was computed, based on an analysis of data obtained from 33 IT professionals in six Korean firms. The analytical hierarchical process (AHP) developed by Saaty (2005) was used to rank the identified CSFs. We believe that this study can help provide a better understanding of the requirements for Web-based systems development efforts. The main steps employed for ranking the CSFs for Web-based systems development are summarized in Figure 1.

WHAT ARE 'WEB-BASED INFORMATION SYSTEMS'?

The term 'Web-based information systems' has been used in many prior studies and white papers. These systems are also referred to as hypermedia information systems, Web applications, and Internet-based information systems. Web-based information systems are defined as application

Figure 1. Steps employed for ranking CSFs for Web-based systems development



programs that run on Internet or corporate intranets or extranets (Chen & Heath, 2005) and deliver content to users on a web-browser. Web-based information systems rely on World Wide Web (WWW), a system composed of hypermedia content and Internet, which allows users to share information in multiple media such as text, video, image, and sound (Bieber & Kacmar, 1995; Bieber & Vitali, 1997; Isakowitz, Stohr, & Balasubramanian, 1995).

Web-based information systems have some unique requirements compared to traditional information systems. For example, Bolchini and Paolini (2000) asserted that Web-based systems development methodologies need to focus on navigation, information architecture, and interface structures. Web-based systems development has to deal with rapid changes and new software tools for hypermedia applications, and to integrate them with existing information systems (Uden, 2002). According to Uden, Web engineering is "a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of hypermedia applications" (p.47). Web-based applications, unlike traditional applications, are implemented using advanced technologies and multi-tier architectures (Navarro, Fernandez-Valmayor, Fernandez-Manjon, & Sierra, 2004). As Web-based systems employ navigational structures and use multimedia content to provide hypermedia characteristics, it is hard to directly employ traditional models and software engineering into the design of hypermedia applications (Garzotto, Mainetti, & Paolini, 1995). Besides navigational structures and the use of multimedia content, it is necessary for hypermedia systems to handle structured and non-structured data, manage access points, maintain high quality of graphics and presentations, and customization and dynamic adaptation of content structures (Navarro et al., 2004). Other researchers have also provided similar summaries of the unique characteristics of Web-based applications: need for rapid change in Web-based applications, divergent data/information types in systems, anonymous users, content-driven systems, creativity, and presentation focused applications (Murugesan & Ginige, 2005), multifunctional systems, customer centric development, collaboration and breaking down functional boundaries, radical change over time, and time-criticality (Standing, 2005). Tompa (1989) asserted that even though traditional information systems attempted to increase their functionality to match the requirements of

dynamic Web-based system environments, they were found to be inflexible.

CSFs for the Development of Web-Based Information Systems

Prior scholars have identified factors which play a critical role in the successful development of Web-based application. We reviewed these prior studies and summarized the critical success factors (CSFs) in Table 1. Some of the CSFs for Web-based systems development methodologies (WDMs) identified in the prior literature are likely to be common to traditional information systems environments as well. For example, procedural aspects, which focus on the processes employed within a methodology to accomplish the development of applications (Lang & Duggan, 2001; Murugesan & Ginige, 2005) are likely to be common across Web-based—as well as traditional—development environments. Other factors likely to be common include: requirement elicitation (Homrighausen, Six, & Winter, 2002; Lang & Duggan, 2001), evolutionary procedure and speed of development (Lowe, 2001; Uden, 2002), testing (Hieatt & Mee, 2002; Lam, 2001), communications between members, and participation/involvement of end users (Coughlan & Macredie, 2002). It may also be noted that the identified factors (listed in the first row of in Table 1) seem to be similar to the ones identified as the best practices by Meso and Jain (2006) in their study of the best practices in agile methodologies based on Complex Adaptive Systems (CAS) theory.

However, Web-based information systems are likely to have additional unique characteristics. Therefore, efforts should be made to identify and assess the relative importance of such unique CSFs. Web-related Aspects (WAs) cover only the issues related to the design of Web-based applications and information structure in Web pages. Based on a synthesis of the prior literature, these elements were classified into two main groups: information properties, and risk control.

The unique information properties commonly identified in the prior literature were: navigation structures, information presentation, content management, and integrated information organization (e.g. Garzotto et al., 1995; Ginige, 2002; Yilmaz et al., 2004; Fraternali, 1999; Murugesan & Ginige, 2005). Web-based systems access information from various sources, and transact and redistribute it to users. Therefore integrity/organization of information is one of the major concerns when developing Web-based information systems. Web-based applications typically have more stakeholders than traditional systems, therefore, it is critical to understand and incorporate their needs in designing layout, presentation, navigation, and content (Ginige, 2002).

Risk control is a key issue in Web-based systems due to the networked environment with access to external entities. This heightens the need for enhanced vigilance for ensuring security and privacy while developing Web-based information systems (White & Dhillon, 2005; Chen & Heath, 2005). However, risk management has been frequently treated as an add-on component to an application (White & Dhillon, 2005), rather than an integral part of a system's functional and non-functional properties (Amer, Humphries, & Hamilton, 2005). Based on the above discussion, the elements of Web-related Aspects (WAs) and their operational definitions are summarized in Table 2 and 3.

AHP MODEL AND MEASUREMENT

AHP is an analytical technique to help decision making on a topic of interest based on comparative judgment of multiple respondents. It provides a systematic approach to aggregate comparative ranking responses from several respondents to arrive at weights for each factor.

AHP model consists of a goal and elements that contribute toward its achievement (Saaty, 2005). The AHP model is presented as a hierarchy

Table 1. Critical success factors common in both traditional and Web-based information systems development

Researchers	Factors Suggested												
	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]
Murugesan & Ginige (2005)	O	O	O	O	O							O	
Chen & Heath (2005)	O			O	O			O	O				
Lowe (2001)	O			O	O								O
Howcroft & Carroll (2000)	O												
Uden (2002)	O		O		O								
Murugesan et al. (2001)													
Standing (2005)				O				O	O		O		
Ginige (2002)													O
Norton (2001)				O	O							O	
Lang and Duggan (2001)					O	O							
Hieatt & Mee (2002)		O											
Lam (2001)		O											
Coughlan and Macredie (2002)						O	O						

[1] Evolutionary Procedure
[2] Testing
[3] Speed of Development
[4] Fit with Organizational Needs
[5] Fit with Individual Needs
[6] Communication between Team Members and End-users
[7] Involvement of End Users
[8] Ease of prototyping
[9] Fitness of Architectures into System Environments
[10] Integration with Other Components
[11] Compatibility of Software Modules with Physical Architectures
[12] Database Structure required to Implement System Architectures
[13] Scalability of Architectures for Future Development

that shows the decomposition of the goal into its constituent elements that are arranged in homogenous sets (Teltumbde, 2000). The analytical process computes relative weights for each element based on pair-wise comparisons by respondents. These weights represent the relative importance of each element, which is useful in the analysis to rank the available alternatives for achieving the goal. This method was initially developed to solve resource allocation problems. It has gained

Table 2. Level 1 elements of Web related aspects

Category	Alternatives Level 1	AHP Operational Definition	Prior Research
WAs	[WAs-1] Information Properties	Issues about information quality in Web-based applications.	Garzotto & Matera (1997); Norton (2001); Murugesan & Ginige (2005); Standing (2005); Lowe (2001);Chen & Heath (2005); Amer et al. (2005); White and Dhillon (2005)
	[WAs-2] Risk Control	Issues about risk management for websites, e.g. security, privacy, authentication, etc	

Table 3. Level 2 elements of information properties

Category	Alternatives Level 2	AHP Operational Definition	Prior Research
WAs-1	[WAs-1-1] Integrity of Information	Issues about how well information in systems can be maintained with consistency	Garzotto et al. (1995); Garzotto & Matera (1997); Lowe (2001); Murugesan & Ginige (2005); Standing (2005); Chen and Heath (2005); Ginige (2002); Yilmaz et al. (2004); Fraternali (1999)
	[WAs-1-2] Aesthetic Interface	Issues about how neatly and aesthetically information can be presented on webpages	
	[WAs-1-3] Richness of Content	Issues about how much and valuable information can exist on webpages	
	[WAs-1-4] Ease of Navigating Information	Issues about how easily users can find information, and how well webpages can support users to do	
	[WAs-1-5] Ease of Updating and Maintaining Information	Issues about how concurrently users can update, and thus maintain information up-to-date	

popularity because it can be easily employed to solve multiple objective problems through an interactive solution (Yang & Lee, 1997). Many IS studies have used this method to evaluate IT projects, rank alternatives, and make resource allocation decisions (e.g., Cheng & Li, 2001; Bodin, Gordon, & Loeb, 2005; Teltumbde, 2000).

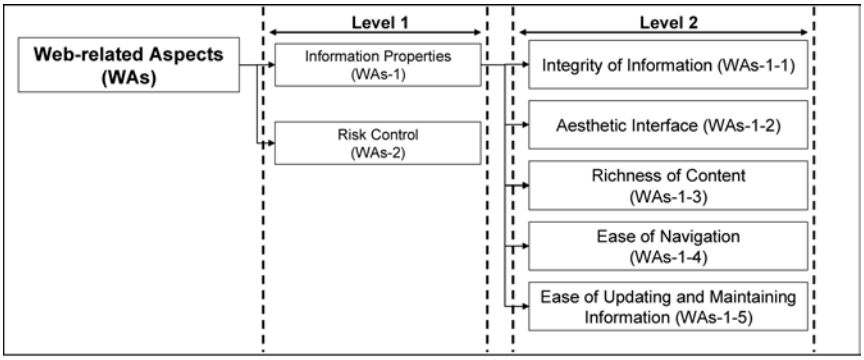
It should be noted that consistency of responses within a respondent and across respondents is an important issue. Thus, Satty (2005) suggested consistency ratio (CR) as an index to evaluate the consistency of responses within a respondent and across respondents. CR values below 0.1 indicate good consistency. If CR is more than 0.1, it means that responses are inconsistent. Satty suggested a three-step approach to deal with low consistency: 1) identify the most inconsistent response in the matrix, 2) assess the range of feasible values to which it should be changed to gain consistency, and 3) ask the interviewee who made the inconsistent judgment to consider changing his/her values to one of the feasible values.

AHP model for this study is presented in Figure 2. This hierarchy structure was prepared based on the CSFs identified in the previous sections. In this paper, the goal of AHP is to understand relative importance of CSFs for Web-based systems development. The identified elements and their subsets are grouped based on their homogeneity. Each element is then divided into conceptually homogeneous subgroups. For example, Web related aspects are divided into information properties and risk control. Each element is compared against other elements at the same level for assessing the relative importance.

DATA COLLECTION

Consistent with prior applications of the AHP, we developed items for pair-wise comparison of dimensions within each level of the AHP hierarchy. The instrument was screened and pre-tested by 4 MIS researchers and 2 practitioners for clarity. Based on the feedback, the instructions and a few items were refined to improve clarity. As the instrument was to be administered in Korea, a researcher translated it into the Korean language. The translated document was cross checked by two other competent Koreans. Subsequently, the instrument was administered to 33 IT professionals in Korea in six companies representing three industry sectors: information technology services (ITS), financial brokerage (FB), and telecommunications enterprises (TE). As Table 4 shows, there were 3 companies with 12 respondents in

Figure 2. Hierarchical model for an AHP analysis



ITS, 2 companies with 12 respondents in FB, and 1 company with 9 respondents in TE. AHP does not require large sample sizes (Lam & Zhao, 1998). The number of respondents in this study was considered reasonable, when compared to other recent studies which employed AHP techniques. The IT professionals were interviewed to obtain job related information details and were asked to fill in the questionnaire in one of the authors' presence. The respondents had worked in Web-based systems development for about 7 years on an average (standard deviation 3.88). The number of professionals and the quality of responses obtained appears to be reasonable for the purposes of this study. In particular, Web-based systems began emerging around late 1990s, therefore 7 years of experience represents substantial experience in this nascent field.

RESULTS OF DATA ANALYSIS

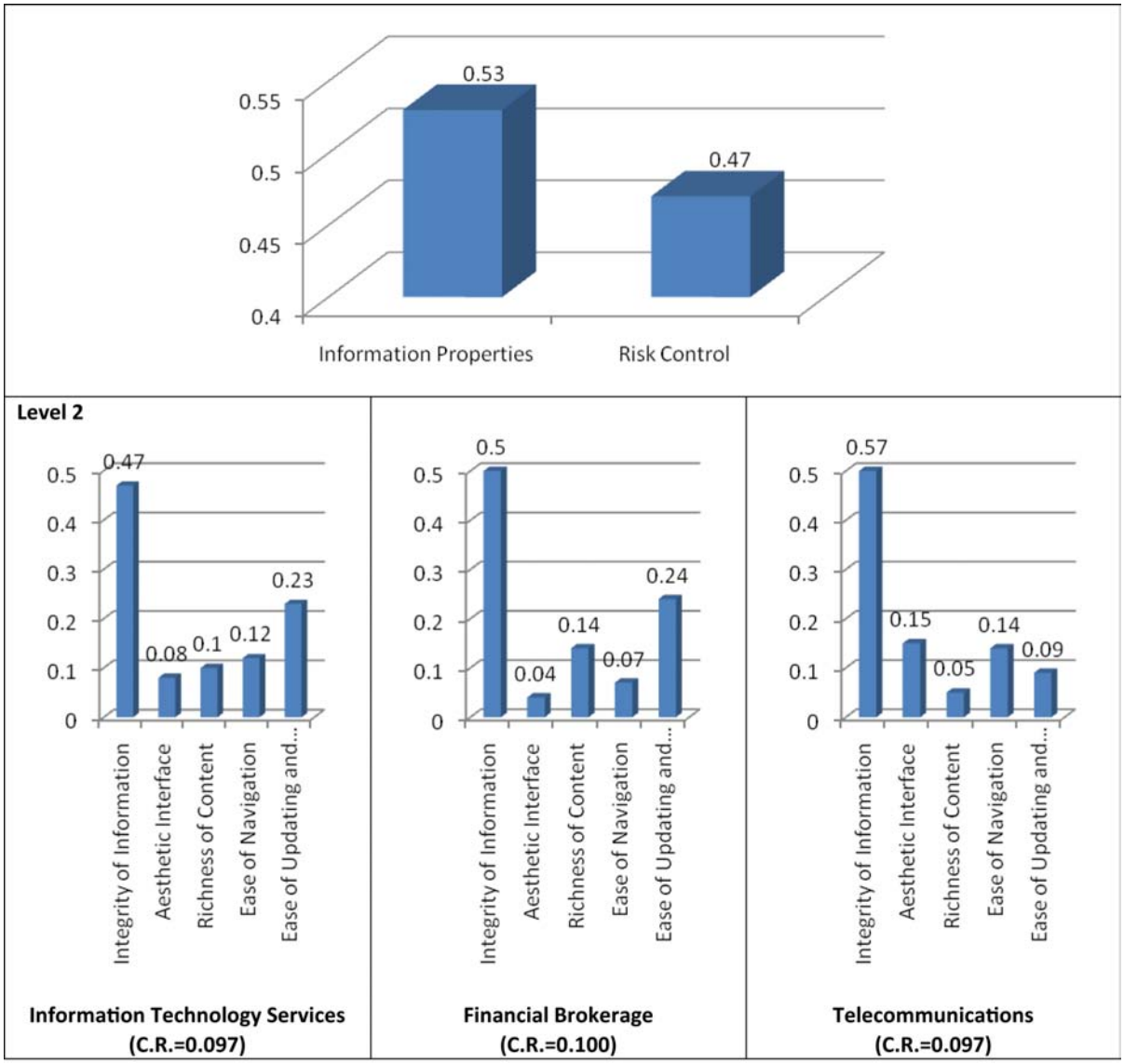
Feedback from the participating IS professionals on the relative importance of elements was used as a basis for determining the weights that can be assigned to each element. The first step in the data analysis was to assess the weights assigned to the two main dimensions at the first level in the hierarchy. The data indicated that for the first level of the hierarchy the weights assigned were similar, with information properties leading (WAs-1) slightly over risk control (WAs-2) at levels of 0.53 and 0.47 (see Figure 3), respectively. An ANOVA analysis confirmed that the differences in the two weights for each of the three industry sectors were not significant (see Table 5).

Next, we analyzed the dimensions at level 2 in the information properties hierarchy (WAs-1). As recommended by Saaty (2005), we calculated the consistency ratios for the level 2 of the hierarchy (WAs-1-1 to WAs-1-5), and found them to be higher than the acceptable limit of 0.1 in some cases. Follow up interviews were conducted with the selected respondents to obtain corrected feasible responses as per AHP procedures, however, the ratio did not improve sufficiently. Therefore, we divided the responses of IT professionals into three industry groups, identified earlier: informa-

Table 4. Profiles of firms and respondents

	Information Technology Services	Financial Brokerage	Telecommunications
Number of Firms	3	2	1
Number of Respondents	12	12	9

Figure 3. Results of AHP



tion technology services (ITS), telecommunication enterprises (TE), and financial brokerages (FB). We felt that dividing the respondents into three groups according to the industry should be reasonable, given that the systems requirements and user interactions of each sector may have their own unique characteristics. We conducted ANOVA analysis on the responses for the level 2 comparisons treating the three industry sectors as independent groups, to explore the differences among the three sectors. As Table 5 shows, the assigned values for each dimension at level two are significantly different from each other for the three industries, except for the comparison responses between rich content (WAs-1-3) and ease of updating and maintaining information (WAs-

Table 5. Results of comparisons among three industries sectors

Items		**F**	**Sig.**
Level 1	Comparison Responses for WAs-1 vs. WAs-2	1.279	.293
Level 2	Comparison Responses for WAs-1-1 vs. WAs-1-2	9.080	.003***
	Comparison Responses for WAs-1-1 vs. WAs-1-3	22.724	.000***
	Comparison Responses for WAs-1-1 vs. WAs-1-4	4.469	.033**
	Comparison Responses for WAs-1-1 vs. WAs-1-5	13.115	.001***
	Comparison Responses for WAs-1-2 vs. WAs-1-3	16.743	.000***
	Comparison Responses for WAs-1-2 vs. WAs-1-4	3.323	.068*
	Comparison Responses for WAs-1-2 vs. WAs-1-5	7.290	.008***
	Comparison Responses for WAs-1-3 vs. WAs-1-4	29.755	.000***
	Comparison Responses for WAs-1-3 vs. WAs-1-5	.423	.663
	Comparison Responses for WAs-1-4 vs. WAs-1-5	9.504	.003***
- Dependent Variables: Comparison responses for a pair of factors from the respondents - Independent Variable: Three Industry Sectors ***** P<0.01 ** P<0.05 * P<0.1**			

1-5). Therefore, we believe that it is reasonable to divide data by industry groups at the level 2 of the information properties dimension (WAs-1).

Figure 3 presents the results of AHP analysis. As the CRs in the table show, all the CRs were below 0.1, indicating good consistency. The survey results show that there are differences in the weights or importance assigned to different elements among the participants in different industry sectors at the lower level.

At the level 2, within information properties (WAs-1), the results indicate that firms in all three industry sectors considered integrity of information (WAs-1-1) to be overwhelmingly important (0.47, 0.57, and 0.50 for ITS, FB and TE respectively). But, for the other items at the level 2 within WAs-1, the results were quite different: the ease of updating and maintaining information (WAs-1-5) was the second highest important factor for the ITS and TE (0.23 and 0.24 respectively) whereas the aesthetic interface (WAs-1-2) and ease of navigation (WAs-1-4) were the next two most important dimensions for the FB sector. We discuss the implication of these results in the next section.

DISCUSSION

With the growing proliferation and usage of the Internet and Web, the importance of Web-based applications has been growing. They have begun to play a critical role in many firms' business strategy and need to the developed in a timely, reliable manner. However, there have been few studies focused on identifying the relative importance of critical success factors for Web-based information system development. In this paper, we identified the unique features required for Web-based information systems development based on a synthesis of the recent literature related to Web-based information systems. AHP approach was employed to assign the relative importance to these features. For the AHP analysis, the data was obtained from 33 IT professionals in 6 Korean firms representing three industry sectors: information technology services (ITS), telecommunication enterprises (TE), and financial brokerages (FB).

At the level 1 of the AHP analysis, we found that the two Web-related aspects, information properties and risk control, were considered equally important by the respondents across the

three industries, with slightly higher importance assigned to information properties over risk control (0.53 and 0.47, respectively). However, at the level 2 of the AHP analysis, significant differences were found among the industries in the relative weights assigned to the five sub-dimensions (WAs-1-1 to WAs-1-5) of the information properties (WAs-1) dimension, as confirmed by ANOVA analysis. Therefore, we considered it advisable to compute relative weights for the level 2 dimensions separately for each industry sector.

On a closer examination of the three sectors, we felt that their information systems environment and Web interactions may be different, and therefore, considering each sector separately should be explored. Information technology services (ITS) firms typically deal with few large corporate clients. They are likely to have fewer customers and internal users. They are also likely to have smaller internal systems and databases. These companies also generally do not carry out significant transactions with customers over the Web. Most the development may involve static webpages. On the other hand, financial brokerage (FB) firms have a very large base of individual customers. They also have extensive internal systems and large databases with an extensive physical architecture. Their customers typically carry out hundreds to thousands of transaction each minute using the Web-interfaces provided to them. Customers may also interact extensively with the websites carrying out many different types of transactions involving dynamic webpages. Telecommunication enterprises (TE) or Internet service providers fall in between the two sectors discussed above. They may have internal systems and databases. However, their websites may or may not carry out high volume of transaction with customers. Thus most of their systems may use static webpages with very few dynamic pages for customer information and interaction.

Based on these differences in organizational needs and usage of Web-based systems for the three industries, the weights for the sub-dimensions of the information properties appear to be reasonable. Across the companies, integrity of information should be considered the most important dimension, given its overall significance in information management. However, for the other sub-dimensions at the level 2, the order of importance assigned reflected the unique industry characteristics and needs. For example, aesthetic interface and ease of navigation were found to be the next two most important dimensions for the FB sector. This appears to be consistent with the requirements of FB firms who need to provide an easy interface to hundred of thousands of customers who may be performing a wide range of financial transactions through their websites. For ITS and TE firms, the next most important factor was ease of maintaining and updating information. This may be reflective of their need to update information content relatively more frequently based on rapid changes in their marketing and product offerings as compared to FB firms.

CONCLUSION AND RESEARCH INSIGHTS

This paper aims at identifying unique critical success factors and their relative importance for the development of Web-based information systems. Interestingly, we found that the relative importance of the critical success factors relies in part on the industry sector. In other words, while the respondents in this study generally agreed that information properties are more important than risk control, they showed divergence in their judgment of how information properties could be enhanced, contingent on the industry sectors in which they were involved.

This result seems to be in line with Chiasson and Davidson's (2005, p. 601) argument "… industry represents an increasingly important influence on the patterns and meaning of IS activities and that more attention to industry in IS theory and research warranted… industry provides a contextual space,

grounded in institutional theory, to evaluate the boundaries of IS theories." This industry effect has been also addressed as collective action (e.g., Markus, Steinfield, & Wigand, 2006). The results of this study along with the two prior studies call for attention to the investigation of the uniformity of the critical success factors across different industry sectors. In addition, other prior studies argued that information systems success factors would be different due to corporate contexts (Bradely, Pridmore, & Byrd, 2006) and that a best practice that is suitable for an environment may not guarantee successful information system development in other environments due to firm level contextual differences (Meso and Jain, 2006). These two prior studies also suggest a series of research questions related to the importance of the firm-level context.

Based on the above analysis we can propose the following research questions:

1. Is there an industry specific effect on the critical success factors for Web-based information systems development?
2. Is there a firm specific effect on the critical success factors for Web-based information systems development?
3. Between the industry and firm specific effects on critical success factors, which effect is more salient for Web-based information systems development?

LIMITATION

This research may have a few limitations that should be kept in mind while interpreting the results. Satty (2005) states that the AHP analysis can be employed with even a few respondents. Some other studies have used as few as two respondents. This survey included 33 professionals from Korea. Therefore, caution should be used in generalizing the results to other settings. Future research should explore the issues considered in this research in the context of other countries to arrive at a more generalizable set of results. Future research should also investigate other industry sectors to identify their unique requirements and find ways to address them with appropriate software engineering methods. The results of this research and future research in this area might provide useful information and guidance for the development of methodologies that may focus on Web-based systems development.

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Chapter 15
Media Richness in Online Consumer Interactions:
An Exploratory Study of Consumer–Opinion Web Sites

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ABSTRACT

Consumer-opinion Web sites provide people with unparalleled opportunities to articulate their opinions on products and services, read those of others, or interact with other consumers. The success of such Web sites is limited by three challenges: the quality of contributions, users' motivation to participate, and readers' trust in the writer's competence. Drawing on the concept of media richness, this article investigates how such Web sites could provide richer and more useful exchanges to both consumers and companies. The results suggest that consumer-opinion Web sites can provide richer exchanges when they separate the tasks of information exchange and social interaction and support them with appropriate levels of richness.

INTRODUCTION

Consumer-opinion Web sites enable consumers to voice their opinions on products, services, and companies, read those of others, or interact with other consumers. Thanks to the proliferation of consumer-opinion Web sites and the persistency of the textual records consumers produce, companies and consumers alike can harvest the Web for opinions about particular products and services (Tapscott & Tiscoll, 2003). To consumers, these Web sites are sources of pre-purchase or post-purchase product information. To companies, meanwhile, consumer-to-consumer (C2C) interactions on the Web render an important feedback function, helping them to gather marketing intel-

ligence from the experiences people report about products and services. The goal of this article is to identify strategies that render the information disseminated on consumer-opinion Web sites more valuable to both consumers and companies. It first explores the nature of consumer-opinion Web sites and then draws on media richness theory to explore the communicative richness of a sample of consumer-opinion Web sites.

THE NATURE OF C2C INTERACTIONS

Consumers interacting on the Web can be viewed from three different conceptual angles. First, consumer interactions—both off-line and online—fall into the realm of word-of-mouth communication. Second, interactions on the Web can be looked at from the perspective of virtual communities and, third, the traces consumers leave on the Web constitute knowledge bases companies can harvest to gather marketing intelligence.

C2C Interactions as Word-of-Mouth

Word-of-mouth (WOM) is defined as non-commercial, oral, communication between two or more consumers (Arndt, 1967). WOM is used particularly when buyers perceive the risk associated with a purchase as high (Haywood, 1989). Its non-commercial nature makes it more influential on consumers' purchasing decisions than advertisements (Day, 1971). In general, WOM among consumers incorporates three different activities. First, consumers seek information for immediate use aimed at risk reduction. Second, they obtain and store information for future usage, and, third, they share it in order to influence other people's decisions (Lampert & Rosenberg, 1975). With the advent of the Internet in private households, WOM communication is no longer an oral activity. It has moved to the Web, where consumer-opinion Web sites facilitate WOM communication. In WOM communication, source credibility is an essential requirement for the persuasiveness of a message. It depends on the receiver's perception of the sender's trustworthiness and expertise (Kiecker & Cowles, 2001). Accordingly, consumers have been found to turn to personal contacts for reassurance and to people they know only loosely for their expertise (Duhan, Johnson, Wilcox, & Harrell, 1997).

On the Web, source credibility is more critical than off-line due to the visual anonymity of participants in computer-mediated interactions. The Web's visual anonymity even enables companies to praise their own products or badmouth those of competitors on consumer-opinion Web sites. However, in online consumer interactions, people's lack of trust in other people's expertise is moderated by their product involvement and product knowledge (Xue & Phelps, 2004). Thus, people who are knowledgeable in a particular product group are in a better position to judge whether a product review is credible and valuable to them. Still, trust in the information provided by others has been found to be a major challenge for opinion platforms on the Web (Hansen, Rezabakhsh, & Bornemann, 2005; Rezabakhsh, Bornemann, Hansen, & Schrader, 2006) and thus also for consumer-opinion Web sites. Therefore consumer-opinion Web sites need to enable participants to learn more about each other rather than rely on people's self-proclaimed expertise, as the development of trust takes time and requires self-disclosure on the part of both interactants (Weber & Carter, 1998).

C2C Sites as Virtual Communities

Interaction in virtual communities satisfies people's information needs as well as their needs for social interaction, either in chat rooms with co-present users or on bulletin boards with temporally disjointed users (Mann & Stewart, 2000;

Stafford & Stafford, 2001). Similarly, previous research on consumer-opinion Web sites indicates that consumers visit these sites to gather product information before or after a purchase or to interact with other consumers. Their desire for social interaction is driven by their concern for others and by their desire to enhance their own self-worth (Hennig-Thurau & Walsh, 2003). Companies may benefit when people visit virtual consumer communities, if consumers read a large number of favorable messages about these companies' products, since consumers' exposure to favorable brand or product evaluations leads to more favorable attitudes toward the brand (Chiou & Cheng, 2003).

However, even active and successful virtual communities are often characterized by an asymmetry of activity (Rafaeli, Ravid, & Soroka, 2004), with a small group of very active participants and a large group of silent participants (Baym, 2000; Ling et al., 2005; Smith, 1992). These lurkers read contributions, but never contribute anything to the community. Explanations offered for this passive participation include the lurker's intention to learn about the community before posting, usability problems, privacy concerns, free-riding behavior, and the lurker's perception of being helpful by not posting (Preece, Nonnecke, & Andrews, 2004; Rafaeli et al., 2004). Although the non-public behavior of lurkers shapes their attitudes about the community (Nonnecke, Andrews, & Preece, 2006) and about the content they are exposed to (cf. Takahashi, Fujimoto, & Yamasaki, 2003; Zajonc, 1974), they still need to be motivated to make valuable contributions, given that participation is what makes or breaks online communities. Since computer-mediated communication occurs in writing using IT infrastructures, it requires more motivation from participants than oral communication. Thus, a second challenge for consumer-opinion Web sites is motivating people to participate actively.

C2C Interactions as Sources of Knowledge

Consumers voicing their opinions on the Web are valuable sources of knowledge not only to other consumers but also to companies. While consumers may learn what aspects to pay attention to before they make purchasing decisions, companies may learn about customer preferences, product defects, service mishaps, and usability problems on their Web sites (Dave, Lawrence, & Pennock, 2003; Nah, Siau, Tian, & Ling, 2002; Warren, 2002). Ideally, companies translate this negative feedback into opportunities for product modification or Web site improvements (Cho, Im, Hiltz, & Fjermestad, 2002), meet customer expectations more closely in the future, or develop new products (Pitta & Fowler, 2005). Before consumer opinions were available on the Web, companies could gather opinions about their products or those of competitors only in the form of surveys, often conducted by external consultants (Liu, Hu, & Cheng, 2005). To gather feedback from online C2C interactions, companies will need to understand many-to-many communication models and learn how to process the information that is available to them in these knowledge bases (Maclaran & Catterall, 2002).

A third challenge associated with consumer interactions on the Web is thus the quality and format of contributions. Quality of content has been found to be a major success factor of member-generated content on the Web (Leimeister & Krcmar, 2005; Ridings & Gefen, 2004). The value of information consists in its relevance, criticality, and accuracy (Kam & Chismar, 2006), all of which are capable of satisfying consumers' and companies' information needs. The inaccuracy and subjectivity of individual experiences are not a challenge for the large-scale collection and analysis of consumer opinions (*Turner,* 1980). However, writers frequently post emotive raves or rages with little information value rather than reviews that add value, as they seem to be in a state

of strong emotional arousal when they share their experiences with others (Pollach, 2006). Further problems encountered in extracting information from consumer opinions on the Web include the large amount of short reviews (Dave et al., 2003), information reporting personal stories rather than focusing on the product's performance (Hu & Liu, 2004), information that does not express opinions or evaluations but provides descriptive background information about the product, and, ultimately, ironic remarks, which are considered noise in the information extracted (Chaovalit & Zhou, 2005).

RESEARCH DESIGN

Previous research on C2C interactions on the Web has primarily focused on C2C auctions (e.g., Boyd, 2002; Dellarocas, 2003, 2006; Dholakia, 2005; Mollenberg, 2004; Ono et al., 2003; Standifird, 2001), while communicative aspects of consumer interactions have not been paid much attention to. Relevant studies conducted in this area have looked at the persuasiveness of C2C communication on the Web (Xue & Phelps, 2004), the effect of positive and negative messages on consumers' brand evaluation (Chiou & Cheng, 2003), the use of online communities for marketing (Evans, Wedande, Ralston, & Van't Hul, 2001; Maclaran & Catterall, 2002; Tapscott & Tiscoll, 2003), consumers' reasons for visiting C2C Web sites (Hennig-Thurau & Walsh, 2003), and their motivation to voice their opinion on C2C sites (Hennig-Thurau, Gwinner, Walsh, & Gremler, 2004). These articles are anchored in the fields of marketing, information systems, but have not viewed C2C interactions as communicative exchanges.

Research Question

The aforementioned literature review suggests that Web-mediated interactions among consumers are subject to three different challenges: Establishing trust in the writer's expertise, motivating users to voice their opinions, and raising the quality of consumers' contributions in C2C interactions. Clearly, these challenges do not exist in isolation but are interrelated in several ways. First, trust in a writer's expertise may be dependent upon the quality of the contributions the writer makes. The quality of contributions, in turn, may depend on they way in which users are motivated to make useful contributions. Conversely, high-quality content has been found to attract new users and thus also potential writers (Leimeister & Krcmar, 2005). Also, every contribution to a consumer-opinion Web site increases the overall information value of the Web site and moderates the effects of manipulation activities undertaken by companies (Dellarocas, 2005), which makes the information provided on the Web site more trustworthy. Ultimately, when people have more trust in a Web community, they may be more willing to contribute to the Web site. The goal of this article is to identify strategies that render the information disseminated on consumer-opinion Web sites more valuable to both consumers and companies by overcoming the challenges outlined previously.

Conceptual Framework

This article is grounded in media richness theory, focusing on the interactional structures and tools available to participants in communicative exchanges on consumer-opinion Web sites. Previously, media richness has been applied primarily to interpersonal electronic media, including e-mail (e.g., Carlson & Zmud, 1999; El-Shinnawy & Markus, 1998; Fulk, 1993; Suh, 1999; Webster & Trevino, 1995) and computer-supported work groups (e.g., Burke & Chidambaram, 1999; Chidambaram, 1996). Further, Simon and Peppas (2004) have studied how media richness affects users' attitudes toward a Web site. Apart from this study, it appears that little attention has been

paid to the media richness of Web sites, although there is a close link between Web site design, Web usability, and media richness (Palmer, 2002). Originally proposed as a theory in the realm of managerial communication, media richness theory suggests that media can be high or low in richness, which is defined as "the ability of information to change understanding within a time interval" (Daft & Lengel, 1986, p. 560). The richness of a medium depends not so much on its characteristics as on its appropriateness to perform a given task (Dennis & Valacich, 1999). While leaner media suffice for unequivocal messages, richer media can improve task performance when complex messages are to be conveyed (Daft & Lengel, 1986). Also, users of electronic media perceive greater richness as they gain experience with them (Burke & Chidambaram, 1999; Carlson & Zmud, 1999; Chidambaram, 1996).

Media richness theory argues that a medium's richness depends on its capacity regarding four parameters: immediacy of feedback, multiplicity of cues, language variety, and personal focus. Immediacy of feedback takes into account whether and how quickly the sender can obtain feedback from the receiver, while multiplicity of cues refers to how many cues senders can convey about themselves. The parameter of language variety considers how a medium can serve to increase understanding among communicators by transmitting verbal and non-verbal information as well as signs and symbols (Daft & Lengel, 1986). Although in this sense written communication conveys less information than oral communication, computer-mediated communication has means unavailable in conventional written communication, for example, hyperlinks or animations, thus providing richer interactions than non-digital written formats such as letters or faxes. Personal focus refers to whether a medium is capable of conveying information about the emotional state of the sender. Since senders have greater presence in an exchange if they are able to communicate feelings and emotions, richer media create a more positive affective state in the receiver than leaner media (Daft & Lengel, 1986; Daft, Lengel, & Trevino, 1987; Lengel & Daft, 1988; Strongman, 1996).

Face-to-face communication is considered to be the richest medium, since its participants are able to give rapid feedback, communicate cues other than language (e.g., physical appearance, body language, tone of voice, or eye contact), use natural language to convey a wide range of meanings, and can communicate feelings easily. Interactive media such as telephone or e-mail are considered to be leaner than face-to-face conversations but richer than static, written communication (Lengel & Daft, 1988). Feedback in electronic media is always less immediate than oral communication—irrespective of whether synchronous or asynchronous—as typing a message inevitably causes a delay in transmission (Dennis & Kinney, 1998). Since many of the social cues we are used to in the physical world are absent in online interactions, the Web's capacity to convey social cues is lower than that of other channels (Donath, 1999). In the absence of these cues, a writer in computer-mediated communication tends to lose in presence compared to the speaker in a face-to-face conversation (Tanis & Postmes, 2003), but may have more presence when using avatars, which are graphical icons typically displayed together with a person's screen name. Avatars increase people's visual presence in online interactions, particularly if they choose to display pictures of themselves (Waskul & Douglass, 1997). Avatars can also communicate attitudes and feelings, for example if they depict an emotionally expressive face (Fabri, Moore, & Hobbs, 2004). Still, the exact position of Web sites along the continuum between face-to-face and written communication is difficult to determine, since they may provide anything from mere textual information to interactive multimedia applications (Palmer, 2002).

Data Collection

The sample Web sites were found in the *Yahoo Directory* under Consumer Opinion (Yahoo Directory, 2006), which contained links to 31 consumer-opinion Web sites in 2005 and to 28 sites in 2006, including four sites not included in 2005. The *Google Directory* did not have a corresponding category containing chiefly consumer-opinion Web sites and was thus not considered for drawing the sample. From the total of 35 consumer-opinion Web sites found via the *Yahoo Directory*, 16 were excluded, because they were not available at the time of data collection, provided information for consumers but did not facilitate C2C interactions, were in a language other than English, contained only sponsored links, or were just alternative URLs to other sites listed in the directory. The resultant sample consisted of 19 Web sites, all of which enable consumers to voice their opinions about products (see Table 1 and Appendix A). A user account was opened with each site in order to gain access to all features offered.

Media richness theory provides a scheme for organizing and understanding the design features offered by C2C Web sites, which helps to identify ways of making them more suitable for the tasks they seek to perform. This study applies the techniques of content analysis to features of Web sites (cf. Ghose & Dou, 1998; Schultz, 1999; Robbins & Stylianou, 2003; Zhou, 2004). The strengths of this approach lie in the unobtrusive, systematic, and replicable collection of data (Krippendorff, 1980).

Table 1. Basic interaction formats

	DI	CO	PR	RE	QU	RA	BL	CH	WK	RG
AskAnOwner					•					
ComplaintBook		•								
Complaints		•								
ConsumerReview	•			•						•
Dooyoo				•						•
Epinions	•			•						•
JudysBook				•	•					•
MarketMarks		•	•		•					
My3cents	•	•	•	•			•			•
PlanetFeedback		•	•		•					•
Ratings				•		•				•
ReviewCentre	•			•		•				•
Riffs				•		•	•	•	•	
RipOffReport		•								•
SafetyForum	•									
SqueakyWheel		•								•
SyllasForum	•									•
TCCL	•	•	•					•		•
uSpeakOut	•									•
Total	**8**	**8**	**4**	**8**	**4**	**3**	**2**	**2**	**1**	**13**

In the absence of a pre-existing coding scheme for such a study, a coding instrument was developed that makes for the systematic and unbiased collection of data from the sample Web sites. The development of the coding instrument was guided by the four parameters of media richness. Following the methodologies of previous Web site content analyses (Ghose & Dou, 1998; Hart, Doherty, & Ellis-Chadwick, 2000; Robbins & Stylianou, 2003; Zhou, 2004), a pilot study of the interactional structures of the first nine Web sites from the alphabetically ordered list of sites was performed to identify as many different features and tools as possible that enable feedback, multiple cues, language variety, and personalized messages. The pilot study resulted in 25 relevant codes capturing particular site features that represent one of the four parameters of media richness. These inductively derived codes (cf. Strauss & Corbin, 1990) were factual codes, which denote clearly defined facts, unlike referential codes, which represent themes in a document (Kelle & Laurie, 1995). The scales used to measure these facts were nominal, taking into account the presence or absence of a particular feature. In content analysis, nominal scales do not require human judgment and interpretation to the same extent as, for example, ordinal scales and thus reduce coder bias.

Subsequently, all 19 sites were examined for the presence or absence of the 25 features derived from the pilot coding. To ensure consistent and accurate data collection, a pro forma data collection document was created to record the presence or absence of these features for each Web site in the sample. Since the study is exploratory in nature, the coding scheme was open for new codes that emerged throughout the coding process. In fact, two new codes emerged during the coding process, and sites already coded were then recoded for the presence or absence of these two features (cf. Ellison, Heino, & Gibbs, 2006; Schultz, 1999). Ultimately, the coding scheme included 27 codes (see Appendix B). All sites were revisited and re-coded as a check on intra-coder reliability (cf. Bauer, 2000; Stempel & Wesley, 1981), reaching an agreement of 99.61%.

Results

The 19 C2C sites differ substantially in the interaction formats they offer. As Table 1 shows, the sites enable consumers to express themselves in a variety of formats, including discussion threads (DI), complaints (CO), praises (PR), product reviews (RE), questions (QU), product ratings (RA), consumer blogs (BL), chats (CH), and wikis (WK). Further, Table 1 indicates how many sites require users to register (RG) in order to actively participate in such interactions. Reading contributions is possible without registration on all sites.

Only six sites explicitly say where their funding comes from, namely from donations, advertising space, and paid memberships of consumers or companies. *TheSqeakyWheel* even charges individuals a fee of $5 for its services, including a complaint posted on the Web site and an e-mail sent to the company the consumer has a complaint against. *ComplaintBook* and *MarketMarks* set up Web-based complaint systems for companies against payment of a fee. A total of 14 sites use banner ads or sponsored *Google* links. Further, two sites have shopbots, from which they may make money by charging the retail outlets included. Only one site neither states where its funding comes from nor has banner ads or levies fees.

Feedback

The 19 C2C sites use almost exclusively asynchronous feedback mechanisms. In fact, *TCCL* and *Riffs* are the only Web sites facilitating synchronous feedback in the form of online chats. Asynchronous feedback on C2C Web sites includes comments on product reviews (12), e-mails

(10), replies in discussion threads (8), ratings of the usefulness of a product review (9), company rebuttals to complaints (6), personal messages among registered users (6), replies to questions (4), and wiki interactions (1). *My3Cents* even threatens to remove reviews that receive a low rating.

Feedback facilities can also be looked at in terms of the parties involved. While only 11 sites offer one-to-one consumer communication (i.e., PM, e-mail, chat), 16 sites post one-to-many feedback from consumers (i.e., ratings, comments, replies in threads), and six sites enable companies to provide feedback on consumers' opinions in the form of rebuttals. Only one C2C Web site does not include any feedback mechanisms at all, confining interactions to message transmission and reception. To some extent, also the operators of the C2C sites give feedback to the contributors as well. While some of them merely claim that they reserve the right to remove inappropriate or offensive messages, two sites claim to approve all reviews before they post them online, and two Web sites automatically screen all messages for offensive words and censors them. One complaint site even promises to e-mail complainants if a lawsuit against the respective company is filed so that they can be a party to it.

While the majority of sites rely on voluntary contributions, six sites offer financial or material incentives to contributors, which also function as a feedback mechanism. The incentives offered include cash rewards for every 100th review submitted by registered members or credit points that are redeemable for products or cash and are earned either for each review or each time the review is read.

Multiplicity of Cues

Allowing members to provide information about themselves when they register is one way to remedy the Web's reduced capacity to convey social cues. Twelve sites enable users to make such information available in their member profiles, including for example information such as location, gender, occupation, e-mail addresses, verbal biographies, hobbies, and links to personal Web sites. On 10 sites, user profiles also include statistics about the user's activities on the site, for example, the number of contributions by the user, the join date, the number of credit points earned, the average rating he/she has received for his/her contributions, the number of visits, the date of the last visit, and the average response time.

C2C sites also provide cues regarding the status of individual users in C2C communities. Two sites provide rankings of their contributors either on the basis of the number of credit points they have earned or on the number of contributions they have made to the site. Six other sites award titles based on the quality (e.g., *top reviewer*) and quantity (e.g., *senior member*) of users' contributions. *ReviewCentre* does not award titles to users but to their contributions, labeling high-quality reviews as *expert reviews*. Similarly, registered members on *Dooyoo* can nominate reviews for inclusion in the site's *Hall of Fame*.

Another way of determining a user's status in a C2C community is by enabling registered members to indicate in their profiles which users in the community they trust in terms of expertise. These buddy networks people create when they add people to their list of trusted members may help others to decide whether or not to trust a reviewer. Overall, four sites offer such reputation systems. On five sites, a user's profile includes both a list of people he/she trusts and a list of those he/she is trusted by.

Language Variety

All C2C sites in the sample enable people to articulate their opinions publicly using natural language, for example, discussion threads, blogs, chats, product reviews, comments, questions and answers, complaints, and praises. However, only one site gives writers the opportunity to check their spelling before they post their messages.

The texts can be enhanced with active hyperlinks on six sites, for example, to link to the sites of companies or products that writers are reviewing. Six sites also enable writers to paste pictures into their messages. Similar to hyperlinks, pictures may help people to provide evidence for their arguments for or against a company or a product. Three Web sites inviting verbal reviews offer a default structure that encourages readers to deal with positive and negative aspects of a product in their reviews.

Eight sites use categories in addition to verbal statements in the form of Likert-scale questions or closed-ended questions. These communication formats clearly limit people's means of expression to a predefined set of answers and introduce a response bias as they suggest ideas and cannot account for qualifications to responses (*Blunch, 1984).* Such ratings appear in two different formats. First, people can rate products or companies according to predefined criteria (e.g., customer service, ease of use, shipping, price, etc.). Second, they can rate the usefulness of other consumers' contributions, for example, "Was this review very helpful/helpful/somewhat helpful/not helpful to you?" or just "Was this review helpful to you?." Although such data can be analyzed more easily than verbal product reviews, they provide only meaningful information if large numbers of users make use of these rating facilities.

Personal Focus

Six of the C2C Web sites enable people to use a selection of emotive icons to express sentiments such as fear, boredom, sympathy, or uncertainty, which sequences of ASCII characters cannot convey as unequivocally as graphic icons. Thus, such interactions are richer than those in which people can use either only ASCII-code emoticons in texts or no emoticons at all because opinions are to be expressed in the form of ratings.

Another factor determining how much presence a writer has in computer-mediated communication is whether or not they post their contributions anonymously, use a screen name, or use their real names. On four sites people can voice their opinions anonymously, on three sites they are strongly encouraged to use their real names, and on 12 sites they can register any name as a screen name. Consumers also have the possibility to express feelings, emotions, and attitudes when they select screen names. Examples of such screen names found on C2C Web sites include, for example, *unhappy consumer*, *ripoff,* or *madandupset*. Avatars, which enable people to express emotions and attitudes, can only be used on five C2C sites, which means that interlocutors do not have much visual presence in the C2C interaction systems studied.

DISCUSSION AND IMPLICATIONS

Discussion of Findings

Media richness theory argues that leaner media suffice to convey simple messages, while task performance improves when richer media are used to convey complex messages. The tasks performed by users of consumer-opinion Web sites are threefold, including (1) passive information gathering (i.e., reading) before or after a purchase or as part of social interactions, (2) active information gathering (i.e., asking) before or after a purchase or as part of social interactions, and (3) information dissemination to share information after a purchase or as part of social interactions (cf. Hennig-Thurau & Walsh, 2003; Hennig-Thurau et al., 2004; Lampert & Rosenberg, 1975). The messages produced and consumed when performing these tasks represent different levels of complexity. Passive information gathering is complex, given that the relevant information has to be found first and then several or possibly many different viewpoints have to be processed. Reading stimulated by the need for social interaction is clearly less

challenging, as an interactant will only respond to one message of his/her choice at a time. Writing, meanwhile, involves complex messages, if the writer seeks to produce a comprehensive and accurate product review, but results in less complex messages, if the purpose of writing is to vent emotions or interact with others.

Thus, to be successful, consumer-opinion Web sites need to offer a high level of richness to those users producing or consuming complex messages, but at the same time they must not overwhelm those consumers exchanging less complex messages. Further, C2C sites need to have mechanisms in place that motivate people with an opinion to share it, ensure high-quality contributions, and build trust among users. The Web sites examined have implemented a number of measures intended to render contributions to these sites richer and thus more valuable. Table 2 summarizes these measures, indicating which parameter of media richness they belong to, which challenge they address chiefly, and how many sites have implemented them. Essentially, the measures listed in this table represent a non-exhaustive inventory of success factors for consumer-opinion Web sites, given that they enhance the richness of C2C interactions and help overcome the three challenges outlined previously.

Enhancing Trust

On the C2C sites examined, trust is generated through feedback mechanisms, social cues, and language. Feedback mechanisms could enhance user trust when companies are given the opportunity to respond to complaints posted on a C2C Web site, as this may raise the site's overall credibility. More importantly, though, member profiles serve as trust mechanisms by decreasing the anonymity inherent in computer-mediated interactions, in particular, if such member profiles contain links to users' personal Web sites. Also, networks of trust set up among users of a site may raise the trustworthiness of people contributing to the site. Bush and Tiwana (2005) argue that reputation systems allowing users to build publicly visible networks of trust increase the stickiness of a Web site, add legitimacy to users' contributions, and increase their influence in the group. Although trust networks add to the social cues that are transmitted about a writer, they also increase the complexity of the message, since readers must be willing to familiarize themselves with these systems before they can understand the cues they transmit. From a game theoretical perspective, such systems also have limitations, if users can register as many different names as they want to and can add their other personas to their list of trust buddies (Resnick, Zeckhauser, Friedman, & Kuwabara, 2000). This suggests that trust

Table 2. Richness of C2C interactions on the Web

	TRUST	QUALITY	MOTIVATION
Feedback	Company responses [6]	Ratings by readers [9] Reader comments [12] Screening/Reviewing [4]	Credit points [6]
Cues	Member profiles [12] Trust networks [6]		Community titles [6] Rankings [2]
Language	Spellchecker [1]	Verbal expression [19] Default structure [3] Active hyperlinks [6]	
Personal Focus		Emotive icons [6]	

networks need to be complemented with social cues, such as the quantity or quality of a writer's previous contributions. In the sample examined, these include community titles awarded to writers based on the quantity of their contributions or rankings of top contributors based on quantity or quality. Offering privileged status to highly active users or users with favorable ratings motivates them to participate meaningfully and improves the usefulness of the community as a whole (cf. Boyd, 2002).

Language may have a negative impact on trust, if orthographic errors in a typed message abound, suggesting not only that the writer is a poor speller but possibly also that he/she is incompetent (Lea & Spears, 1992). Orthographic mistakes may also entail that contributions are not included in the results of the site's search engine. A spellchecker, which is used on one site only, would remedy this situation to some extent. However, online trust based on language use is not formed by proper spelling alone, but also by correct grammar and syntax (Koehn, 2003), which spellcheckers would be unable to ensure. At the same time, however, spelling errors give the contributions a feel of authenticity that hidden advertising messages posted by companies may not have.

Raising Quality

The quality of contributions in C2C interactions could be improved through measures pertaining to feedback, language, and personal focus. Feedback enriches C2C interactions, as writers are likely to try harder when they know others can respond publicly, for example, when readers can rate contributions or comment on them, when companies can respond to complaints, or when site owners review contributions before they make them available publicly. Together, contributions plus verbal feedback provide a richer picture of a product or a service, even if this means higher overall message complexity. This richness, however, depends on users' willingness to provide such feedback. Giving immediate feedback, for example, verbal comments, clearly requires more effort than less immediate feedback, for example, ratings. In particular, readers may not be willing to provide feedback that rewards the writer but does not provide any rewards for themselves.

Quality is also closely associated with language, as opinions expressed verbally can account for both positive and negative views on a product or a company, unlike opinions expressed by answering multiple choice questions or closed-ended questions. However, verbal expression is inherently complex because of potential ambiguities, repetitions, and stylistic problems. Further, activated hyperlinks may enhance the richness of contributions in C2C interactions, as they enable writers to loosely integrate information from other sources. This gives a broader picture than the information posted on just one C2C Web site can give, but also raises the complexity of the message. Quality in C2C interactions can be enhanced by enabling people to express feelings and attitudes with graphic emoticons, since neither words nor ASCII characters can always express what people convey with facial expressions or intonation in face-to-face interactions. The use of emotive icons may also shorten or eliminate passages verbalizing emotions in consumers' contributions. Such graphic icons are able to make messages more concise by capturing all emotive content and leaving only product-related information in the text. In that sense, emotive icons can reduce the complexity of a message.

Increasing Motivation

Users' motivation to articulate their opinions instead of merely reading those of others could be increased when they collect credit points every time they make a contribution to the Web site. In addition, their motivation could be improved when they are awarded community titles based on the quantity of their contributions or when they appear in rankings of top contributors. This

is in line with Preece et al.'s (2004) argument that rewarding both quantity and quality of contributions is a way of turning lurkers into active participants. Quantity of contributions may also provide an additional cue to the writer's identity, if it demonstrates that the writer has contributed to a variety of product categories, which rules out the possibility that this writer is a product manager promoting products.

Practical Implications

The results offer starting points for making C2C Web sites more useful sources of information. First, the results have shown that adding richness features often increases message complexity. To help users perform their desired tasks, consumer-opinion Web sites need to offer a high level of richness to those users producing or consuming complex messages, but at the same time must not overwhelm those consumers exchanging less complex messages. This suggests that C2C Web sites could provide more valuable interactions when they separate the complex task of information search/dissemination and the less complex task of social interaction, and support each task with appropriate levels of richness. For example, a discussion forum for social interaction could be enriched with member profiles, while product-review facilities for information dissemination could be supported by trust networks and ratings. This separation would enable people to perform information-oriented, complex reading or writing tasks in a richer setting, but would also enable them to perform social tasks involving less complex messages.

Second, language appears to be a parameter particularly worth improving, given that feedback and social cues largely depend on users' willingness to provide them and personal focus is of minor relevance in anonymous consumer interactions. When users rely on WOM communication, they consider negative information to be more helpful than positive information in distinguishing between high quality and low quality products (Herr, Kardes, & Kim, 1991). This suggests that Web site operators should encourage consumers to consider both positive and negative points when stating their opinion on a product, as is currently done by only three C2C Web sites in the sample. When writers are guided by such a structure, their contributions are more likely to contain evaluations of a product rather than personal stories or venting of emotions. However, this structure raises the complexity of messages considerably and should therefore only be encouraged in interactions aimed at information dissemination.

Limitations and Future Research

The study conducted has several limitations. First, the sample was drawn from a Web directory, which is unlikely to include an exhaustive list of consumer-opinion Web sites. There may be other sites that are not featured in the directory used for sample selection. Also, there may be forms of consumer interactions that take place on Web sites that are not exclusively consumer-opinion Webs ites and are thus not included in the directory uses. Second, all sites included in the sample were in English, since Web sites in languages other than English were excluded from the sample in order to draw a linguistically homogenous sample. Third, media richness theory provides a useful conceptual framework for Web site analyses, but clearly does not result in an exhaustive framework of communicative features on C2C Web sites. There may be other useful features on consumer-opinion Web sites that were not included in the analysis, because they do not pertain to any of the four parameters of media richness. Fourth, the study is based on data gathered from Web sites, but does not integrate user perceptions of the features it analyzes. Future research may build on the results of this study, using the features identified as a basis for studying sites in non-English speaking countries. More importantly, consumers who are active

on C2C Web sites should be surveyed about (1) the ways in which they make use of the features identified in this study for information gathering and social exchanges, (2) their perceptions of media richness and message complexity, and (3) their perceived importance of social presence in consumer interactions. Such studies should also account for cultural differences regarding the use of consumer-opinion Web sites in general.

CONCLUSION

Media richness theory has provided a useful framework for analyzing the interaction formats of consumer-opinion Web sites. The feedback mechanisms through which consumers can respond to what others have written may help to enhance trust, quality, and motivation. The social cues that can be conveyed in C2C interactions have implications for trust and motivation. The ways in which people are able to articulate their opinions may impact the quality of contributions and to some extent also the trust reviewers have in others. Ultimately, personal focus may help to improve quality but seems to be only of little relevance in C2C interactions on the Web, given that product-related facts are much more interesting to readers than a writer's emotive state. Overall, the results suggest that there is room for improvement on all the Web sites analyzed in order to make these interactions more valuable to companies and consumers alike. Consumer-opinion Web sites need to take into account the complexity of the tasks their users seek to complete and offer richness parameters that support these tasks. In particular, the results call for a separation of information exchange and social interactions on consumer-opinion Web sites in order to tailor media richness better to the complexity of the task users seek to perform.

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APPENDIX A. SAMPLE WEB SITES

1. http://www.askanowner.com/
2. http://www.clik2complaints.co.uk/
3. http://www.complaintbook.com/
4. http://www.complaints.com/
5. http://www.consumerreview.com
6. http://www.dooyoo.co.uk/
7. http://www.epinions.com/
8. http://www.marketmarks.com/
9. http://www.my3cents.com/
10. http://www.planetfeedback.com/consumer/
11. http://www.ratings.net/
12. http://www.reviewcentre.com/
13. http://www.riffs.com
14. http://www.ripoffreport.com/
15. http://www.safetyforum.com/
16. http://www.syllas.com/
17. http://www.thesqueakywheel.com/
18. http://www.uspeakout.com/
19. http:/www.judysbook.com/

APPENDIX B. LIST OF FEATURES

Table 3.

Feedback	Asynchronous/synchronous, ratings, comments, threads, PM, e-mail, chats, rebuttals, wiki, feedback from site owner, credit points
Cues	Contents of member profiles, user statistics made available, link to personal site, picture of oneself, network of trust, ranking of contributors, titles awarded
Language	Ratings, verbal comments, pros and cons, activated hyperlinks, pictures
Personal focus	Registration, screen name, avatar, emotive icons

This work was previously published in Information Resources Management Journal, Vol. 21, Issue 4, edited by M. Khosrow-Pour, pp. 49-65, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 16
Revisiting the Impact of Information Technology Investments on Productivity:
An Empirical Investigation Using Multivariate Adaptive Regression Splines (MARS)

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ABSTRACT

This article revisits the relationship between IT and productivity, and investigates the impact on information technology (IT) investments. Using the MARS techniques, we show that although IT Stock is the greatest predictor variable for productivity (Value Added), it is only significant as an interaction variable, combined with Non-IT Capital, Non-IT Labor, Industry, or Size.

INTRODUCTION

Information technology (IT) investments by U.S. organizations have steadily increased since the 1980s, and continue to receive the attention of researchers (Lin & Shao, 2006). Although a great number of studies have examined the impact of IT investments on organizational productivity to

quantify the business value from IT, results from empirical studies are largely mixed. Earlier studies were inconclusive (Loveman, 1994; Weill, 1992), but more recent studies show the positive IT impact on productivity at the firm level (Brynjolfsson & Hitt, 1995; Dewan & Min, 1997; Kudyba & Diwan, 2002a, 2002b; Kudyba & Vitaliano, 2003; Lichtenberg, 1995; Menon, Lee, & Eldenburg, 2000; Shao & Lin, 2002). Dedrick, Gurbaxani, and Kraemer (2003) attributed these positive results to better data sets and analytical tools used to measure the true impact of IT investments.

Although there have been many firm level IT & productivity studies, most of them have used either data envelopment analysis (DEA) or econometrics to test the relationship between IT investment and productivity. In this study, we used a relatively new data mining technique - multivariate adaptive regression splines (MARS). This tool overcomes many shortcomings of the traditional approach, which assumes a linear relationship between dependent and independent variables and normality of the error distributions. MARS offers a flexible regression technique that can uncover a range of possible relationships in the data, including nonlinear relationships (if they exist), and may provide additional insight for investigating complex issues, such as the impact of IT on productivity.

While results of the previous studies made significant contribution to IT & productivity studies, we contend that the complexities of the relationship between IT investment and productivity cannot be determined without reviewing the interaction of its variables. In addition, we contend that the relationship between productivity and IT investment is not linear.

While a number of studies have investigated the IT impact on productivity at the industry level, these studies often have contradicting findings. Hu and Quan (2005) found no significance between IT investment and productivity in the IT-intensive industries, while findings from Kudyba and Diwan (2002b) and Lee and Kim (2006) indicated otherwise. Therefore, the purpose of this article is to revisit the relationship between IT and productivity using MARS, and to attempt to quantify the values from IT. In addition, we included contextual variables to investigate if and how these factors influence the overall organizational productivity.

This article is organized as follows: The Literature Review section reviews previous IT and productivity research. This is followed by the Research Model and Hypotheses section. The Methodology section describes MARS, the data set, and the production function. This is followed by the Results and Discussion of Results sections that include MARS analysis and discussion of the empirical results. Next, we compare our results with those of previous studies. The final section provides the conclusions of the article, including suggestions for future research.

LITERATURE REVIEW

Numerous researchers have examined the relationship between IT investment and productivity within a variety of firms and industries. However, findings from these studies have been inconsistent. Following is a summary of previous studies, categorized by their results and level of analysis.

IT Investments and Productivity at the Firm Level

No Significant Relationship at the Firm Level

Loveman (1994) examined 60 manufacturing business units within the U.S. and Western Europe. Despite disaggregating the use of IT according to IT intensity, industry, and market share, he found no significant impact of IT investments on productivity at the firm level.

Hu and Plant (2001) argued that there is causality between IT investment in the preceding years

and performance of a firm in the subsequent year. Instead, they found that improved financial performance of preceding years resulted in an increase in IT investments in the subsequent year.

Positive Relationship at the Firm Level

Lichtenberg (1995) examined the output contribution of computer capital and IS labor and found substantial "excess returns" to both factors. The author claimed that marginal productivity of IS labor is six times that of non-IT labor. When examining IT substitutability for other inputs, Dewan and Min (1997) constructed firm level data following the same approach taken by Hitt and Brynjolfsson (1996) and Lichtenberg (1995). The authors used the Constant Elasticity of Substitution (CES) translog production functions and found that IT capital is a net substitute for both ordinary capital and labor.

Menon et al. (2000) examined IT productivity in the healthcare industry and categorized capital investments into three types: IT capital, medical IT capital, and medical (non-IT) capital. Labor was categorized as IT and non-IT. Their study indicated that non-IT labor showed the highest positive impact on productivity, IT labor and medical IT capital contributed to high productivity, IT capital contributed low average productivity, but non-IT capital showed a negative impact on productivity.

Shao and Lin (2002) found that IT has a positive effect on technical efficiency in the production process, whether IT investments are treated as a firm-specific factor or a production factor. Kudyba and Diwan (2002a, 2002b) compared their empirical results to three previous studies with similar methodologies, and concluded that the increase in productivity from IT increased over time. Kudyba and Vitaliano (2003) investigated the relationship between IT and profitability and found that IT enhances firm level profitability. Lee and Kim (2006) found a positive relationship between IT investment and firm performance, considering the effects of information intensity and time lag.

Mixed Results at the Firm Level

Weill (1992) focused his study on valve manufacturing firms, and found that only transactional IT investments had a positive impact on firm performance, while strategic and informational IT did not. Further, he found that *conversion effectiveness*, which includes the quality of the management and commitment to IT, is a significant moderator between strategic IT investment and performance.

Mahmood and Mann (1993) examined the relationship between IT investments and organizational strategic/economic performance from Computerworld's 1989 "Premier 100" list of firms. Their study indicated that individual IT investment ratios have a weak relationship with individual strategic/economic performance ratios, but the combined effect of IT investment measures has indicated a significant relationship between IT investments and organizational performance.

Hitt and Brynjolfsson (1996) used firm-level data collected from annual surveys conducted by International Data Group (IDG) and supplemented other information from Standard and Poor's Compustat. The authors investigated the impact of IT on three performance measures: productivity, profitability, and consumer value. They found that IT spending has a positive impact on productivity, and provided significant value for consumers. However, they found no improvement in business profitability.

Using the Menon et al. (2000) dataset, Ko and Osei-Bryson (2004a, 2004b) applied the MARS technique to examine IT productivity in the healthcare industry. Ko and Osei-Bryson (2004b) replicated the Menon et al. study, but using the MARS technique rather than linear regression. They concluded that while IT investment has a positive impact, this impact exists only under certain conditions and that a complementary

relationship exists between IT and non-IT investments. Ko and Osei-Bryson (2004a) also applied the MARS technique, using different variables: IT Stock, Non-IT Capital, and Non-IT Labor. IT stock, which represents the combined investment of IT capital and IT labor, has a positive impact on productivity of the healthcare organizations, but this impact is conditioned by the amounts invested in both IT Stock and non-IT capital. However, the impact of Non-IT Labor on productivity is always positive.

Osei-Bryson and Ko (2004) applied the MARS technique to the data set used by Hitt & Brynjolfsson (1996). Their study is based on the Cobb-Douglas production function, based on investment data from 1988–1992. They found that investment in IT stock has a "concave" impact on productivity. IT investment has no impact on productivity until it reaches a threshold level. And, after a certain level of IT investment, firms experience a decrease in productivity. Since they used the Cobb-Douglas production function, they did not study interactions between input variables.

IT Investments and Productivity at the Industry Level

Positive Relationship at the Industry Level

Lee and Kim (2006) found that the effect of IT and a lag effect of IT on performance are greater for firms in the high information-intensive industry than ones in the low information-intensive industry, and a lag effect of IT investment is larger than an immediate effect. Kudyba and Diwan (2002b) indicated that IT-intensive industries (i.e., banking and financial services, computers and electronics) have greater returns to IT capital.

Mixed Results at the Industry Level

Kudyba and Vitaliano (2003) found no relationship between IT impact and profitability of firms in service industries, but found a positive relationship of firms in manufacturing industries. Hu and Quan (2005) investigated the IT investment impact at the industry level, and found a causal relationship between IT investments and productivity in six out of eight industries. However, their results show that IT investments have no significant impact on productivity among the construction and finance industries, which are somewhat different than the findings of Kudyba & Diwan (2002b). Table 1 includes a summary of previous IT and productivity empirical studies.

RESEARCH MODEL AND HYPOTHESES

In light of the previous discussion, the following hypotheses were proposed:

H1: *Investment in IT has a positive impact on productivity at the firm level*

H2: *There exists an interaction effect between IT and non-IT investments*

H3: *The impact of IT on productivity is not uniform across different industries*

H4: *The impact of IT on productivity is not uniform across firm size*

H5: *The impact of IT on productivity is not uniform across year.*

Figure 1 represents our research model, which indicates the relationship between IT investment and firm productivity. Industry, Size, Year, and Non-IT investments are shown as interaction variables with IT investments. These variables also impact firm productivity.

Table 1. Summary of IT and productivity empirical studies

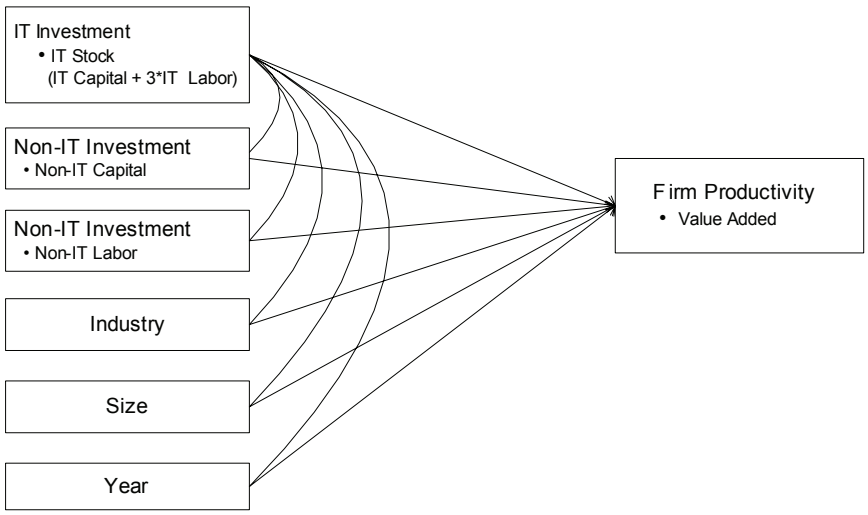
Study	Year Studied	Level of analysis	Methodology	Findings
Weill (1992)	1982-1987	Firm (manufacturing industry)	Hierarchical Regression analysis	• Positive relationship between transactional IT and performance • No relationship between (Strategic IT or informational IT) and performance
Mahmood & Mann (1993)	1989	Firm	Pearsonian correlation analysis, Canonical correlation analysis	• The individual IT measures are weakly related to performance variables • The combined IT measures are significantly related to performance variables.
Loveman (1994)	1978-1984	Firm (manufacturing industry)	Regression analysis	• No relationship between IT investments and productivity
Lichtenberg (1995)	1988-1991	Firm	Regression analysis	• Both computer capital and IS labor have a positive relationship with productivity
Hitt & Brynjolfsson (1996)	1988-1992	Firm	Regression analysis: OLS (Ordinary Least Squares), ISUR (Iterated Seemingly Unrelated Regressions)	• IT investments increase productivity and consumer value • No relationship between IT and business profitability
Dewan & Min (1997)	1988-1992	Firm	Regression analysis (nonlinear least squares and OLS)	• IT Capital is a substitute for both capital and labor.
Menon et al., (2000)	1976-1994	Firm (healthcare industry only)	Stochastic frontier	• A positive relationship between medical labor, IT labor, IT capital, medical IT capital, and productivity • A negative relationship between Non-IT capital and productivity
Hu and Plant (2001)	1990-1995	Firm	Regression analysis (linear least square)	• No causality between IT investment and firm performance • Budgeted IT investment is based on firm's performance of the preceding years
Shao & Lin (2002)	1988-1992	Firm	DEA (Data Envelopment Analysis) and Tobit Regression	• IT (a firm specific factor and as a production factor) has a positive effect on technical efficiency
Kudyba & Diwan (2002a; 2002b)	1995-1997	Firm (2002a) Firm & Industry (2002b)	Regression analysis	• IT investments increase productivity and this increase in productivity increases over time. • High IT-intensive industries increase returns to IT capital (2002b)
Kudyba & Vitaliano (2003)	1995-1997	Firm	Regression analysis	• IT has a positive relationship with firm level profitability
Ko & Osei-Bryson (2004a)	1975-1994	Firm (healthcare industry only)	MARS	• IT has a positive impact but it is conditioned by both IT Stock and Non-IT capital

Continued on following page

Table 1. Continued

Study	Year Studied	Level of analysis	Methodology	Findings
Ko & Osei-Bryson (2004b)	1975-1994	Firm (healthcare industry only)	MARS	• The impact of IT is positive only under a certain condition • complementary relationship exists between IT and non-IT investments
Osei-Bryson & Ko (2004)	1988-1992	Firm	MARS	• Relationship between IT & productivity is positive when it exceeds the level. • a productivity paradox exists if not
Hu & Quan (2005)	1970-1999	Industry	Granger causality model	• A causal relationship exists between IT investments and productivity at the industry level. • IT investments contribute positively to the Manufacturing & transportation industries • Finance industry did not show significance.
Lee & Kim (2006)	1991-1997	Firm & industry	Regression analysis: WLS (Weighted Least Square), Pearson correlation analysis	• IT (or a lag effect of IT) increases performance • The effects of IT are larger in the high information-intensive industry than in the low information-intensive industry. • a lag effect of IT is larger than an immediate effect of IT

Figure 1. The research model



METHODOLOGY

The primary purpose of this study was to revisit the relationship between IT investment and productivity using MARS. Rather than assume a linear relationship, we relied upon a data mining technique, MARS, which would enable us to model and evaluate variables and their interactions. A detailed description of MARS is provided in Appendix A.

Although MARS has not been used in IT productivity research until recently (Ko & Osei-Bryson, 2004a, 2004b; Osei-Bryson & Ko, 2004), it has been successfully applied in various fields. They include biological sciences (e.g., Prasad & Iverson, 2000), communication (e.g., Ekman & Kubin, 1999), electrochemistry (e.g., Carey & Yee, 1992), epidemiology (e.g., Kuhnert, Kim-Anh, & McClure, 2000), finance (e.g., Abraham, 2002), geography (e.g., Abraham & Steinberg, 2001), marketing (e.g., Deichmann, Eshghi, Haughton., Sayek, & Teebagy, 2002) and software engineering (e.g., Briand, Freimut, & Vollei, 2004).

Data Set

Since we are using a different methodology to test the relationship between IT investment and productivity, we wanted to use a data set similar to ones used in prior research. Therefore, we utilized information obtained from *Information Week* (IW) and *Compustat*, which were the source of data used in numerous IT and productivity studies (Bharadwaj, 2000; Dasgupta, Sarkis, & Talluri, 1999; Hitt & Brynjolfsson, 1996; Kudyba & Diwan, 2002a, 2002b, 2002c; Lee & Kim, 2006; Lichtenberg, 1995, Rai, Patnayakuni, & Patnayakuni, 1997; Shao & Lin, 2002). Note that *Information Week* stopped reporting IT investment data in this manner after 1997. Therefore, in order to accurately compare our results, it was necessary to use the older dataset. As indicated by many previous researchers, accessing reliable firm level IT data is difficult, and this is one of the few sources that are available.

Information Week published annual survey results of IT spending by the top 500 IT users in the United States. We collected annual IT budget information from the *Information Week* (IW) 500 surveys for the year from 1994 to 1997. Since these firms are publicly traded, corresponding firm-related financial and other information, such as revenue and expenses, net property, plant, and equipment (PPE), number of employees, industry classification code, and so on, were obtained from the *Compustat* database. The sample included 972 data points. If the firm was presented all four years, it had four data points.

The following input variables—*IT Stock (ITST), Non-IT Capital (NITK), Non-IT Labor (NITL), Size (SIZE), Year (YR),* and *Industry (IND)*—were studied to determine their relationship to the output variable, *Value Added (V)*. The IT budget represents the combined capital and operating budgets that a corporation's chief information officer controls. This includes staff, hardware, software, telecom, and others. The *1994 IW 500* survey reported percentages of the IT budget allocated to each category. According to the survey, the average IW 500 company spends 40% of the IT budget on staff, 22 % on hardware, 13% on software, and 13% on telecommunications. The remaining balance is allocated to numerous smaller items. Out of the total staff expenditure, one third is devoted to new software development and systems installation, another third goes to operations, a quarter goes to maintenance, and the rest is allocated to planning. These percentages were used to calculate input variables for the years 1994 to 1997.

- *IT Stock (ITST)* represents IT investments, and is a composite variable of *IT Capital* plus three times the cost of *IT Labor.* This composite variable was also used in previous studies (Brynjolfsson & Hitt, 1995; Hitt

& Brynjolfsson, 1996; Shao & Lin, 2002; Kudyba & Vitaliano, 2003; Ko & Osei-Bryson, 2004a; Osei-Bryson & Ko, 2004). The variable was based on three years of labor because the capital asset of IT Labor lasts, on average, three years.

  - *IT Capital* represents the IT budget allocated to hardware (PCs and mainframes). The "percentage of the hardware" budgeted for each firm was used from the *1994 IW 500* to calculate the base year *IT Capital* by multiplying it by the IT budget amount. IT Capital for the following years was based on depreciation of the previous year's *IT Capital*.[1]
  - *IT Labor* represents the labor portion of the IT budget. It was calculated by multiplying the IT budget amount reported in the survey by the "percentage of the IS staff" budgeted by each firm and adjusted by the *Index of Total Compensation Cost* (private section), which was published by the *Council of Economic Advisers* 1998.

- *Non-IT Labor (NITL)* represents total labor costs minus the cost of *IT Labor*. It was calculated by multiplying the industry average labor cost per employee by the number of non-IS employees (the total number of employees minus the number of IS employees), deflated by the index of *Total Compensation Cost* (private sector)(*Council of Economic Advisers* 1998).
- *Non-IT Capital (NITK)* represents net PPE less *IT Capital* and is also referred to as fixed assets. Net PPE is calculated by total PPE minus accumulated depreciation, which can be obtained from the Compustat. Not to count twice, *IT Capital* amount is subtracted from it. It was adjusted for inflation using the GDP deflator for nonresidential fixed investments, as published in the *Council of Economic Advisers*.

Industry, Size, and *Year* were included to investigate if and how the impact from IT investment varies with these contextual variables.

- *Industry (IND)* is a categorical variable that categorizes firms into eight industries, based on their SIC code. To be consistent with previous research, we used the same categories that were included in Hu and Quan (2002).
  - *Agriculture, Forestry, and Fishing (SIC 01-09) (AFF)*
  - *Mining (SIC 10-14) (Min)*
  - *Construction (SIC 15-17) (Con)*
  - *Manufacturing (SIC 20 –39) (Man)*
  - *Transportation and Public Utilities (SIC 40-49) (TPU)*
  - *Wholesale and Retail Trade (SIC 50 –59) (WRT)*
  - *Finance, Insurance and Real Estate (SIC 60-67) (FIRE)*
  - *Services (SIC 70-89) (Ser)*
- *Size (SIZE)* is calculated by dividing the firms into two groups: large and extra-large. Since our sample represents the top 500 IT users, these are not considered small firms. Thus, the firm whose total assets are greater than the mean is considered an extra-large firm, and if they are less than the mean, the firm is considered a large firm (Hunton, Lippincott, & Reck, 2003). The mean of total assets was $2,605,000 for large firms and $29,157,000 for extra-large firms. From the sample size of 972 data point, 513 (53%) represented large firms, and 459 (47%) represented extra-large firms.
- *Year (YR)* is a categorical variable, representing the year in which the data was collected. The data included four years from 1994 to 1997.
- *Value Added* [2] *(V)* represents a measure of output that is calculated by gross sales minus variable costs (cost of goods sold (COGS), and selling and general administrative

(S&GA) expenses), adjusted by Producer Price Index (PPI) for Intermediate Materials, Supplies, and Components, as published in the *Council of Economic Advisers* (1998).

A further breakdown of the data is summarized in Table 2, and The IT budget breakdowns and input variables are shown in Figure 2.

Figure 2 is to scale, based on the average IW500 Company spending of IT budget for 1994 and composition of input variables. Allocation of the variables is based upon the following:

- IT Capital = IT Budget * % of Hardware
- IT Labor = IT Budget* % of Staff
- IT Stock = IT Capital + 3 * IT Labor
- Non-IT Capital = Net PPE (as reported by Compustat for the given company) minus IT Capital
- Non-IT Labor = (Number of Total employees – number of IS employees) * Industry average labor cost per employee)

Production Function

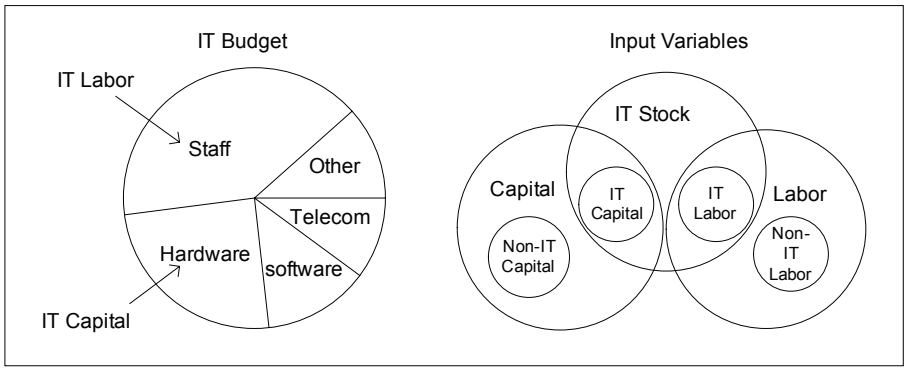
The theory of production assumes that output is a function of various factor inputs, such as capital and labor (Henderson & Quandt, 1980). If value is known, firms are more likely to invest in inputs which provide them with more value than their original cost. In this study, we used the log value of each continuous input variable, because

Table 2. Summary statistics of the data set

Variables	Min	Max	Mean (per firm)	SD	No. of Obs.
Value Added	6.089 ($1.227 M)	10.308 ($20.324 B)	8.752 ($565 M)	.532	972
IT Stock	6.047 ($1.114 M)	9.815 ($6.529 B)	8.085 ($121 M)	.532	972
Non-IT Capital	7.223 ($16.7 M)	10.812 ($64.913 B)	9.106 ($1.276 B)	.639	972
Non-IT Labor	7.037 ($10.9 M)	10.148 ($14.060 B)	8.752 ($565 M)	.461	972
IT Capital	$0.3 M	$2.869 B	$95.7 M		972
IS Labor	$0.2 M	$1.480 B	$58.2 M		972
Total Assets	$10.79 M	$272.4 B	$15.143 B		972

Note: log units are shown first, followed by the actual dollar value expressed in millions ($M) or billions ($B)

Figure 2. The IT budget breakdown and composition of input variables



several theoretical production functions (i.e., Cobb-Douglas, Constant Elasticity of Substitution (CES), and Translog) that are commonly used in IT and productivity studies (Dewan & Min, 1997; Hitt & Brynjolfsson, 1996; Kudyba & Diwan, 2002a, 2002b; Menon et al., 2000) involve the log of the variable, rather than the raw variable. While the Cobb-Douglas production function is simple and most commonly used, the transcendental logarithmic, or "translog" production function is more flexible (Christensen & Jorgenson, 1969), because it does not restrict the values of the elasticity of substitution, and enables the elasticity of substitution to change with output and inputs while the Cobb-Douglas function constrains the substitution elasticity to unity. Also, the translog production function allows for two-way interactions among variables, whereas Cobb-Douglas does not (Evans, Green, & Murinde, 2002). The translog production function and variations of translog production function (e.g., CES-translog) have been used in previous IT & productivity studies (Brynjolfsson & Hitt, 1995; Dewan & Min, 1997). Our production function has the following form:

$$V = f\ (NITK, NITL, ITST, SIZE, YR, IND)$$

While the translog production function uses only numeric variables, the generalized translog production function can include both numeric and categorical variables. A more detailed description of the generalized translog production function is provided in Appendix B.

RESULTS

A generalized translog production function was the basis for our model. Log values for *Non-IT Capital (NITK), Non-IT Labor (NITL), IT Stock (ITST),* and *Value Added (V)* were computed (*Year (YR), Firm Size (SIZE)*, and *Industry (IND)* are categorical variables). We used the MARS (version 2.0 by Salford Systems) software package to estimate a regression splines model, allowing two-way interactions among the input variables. Although the MARS technique allows higher order interactions, we only included two-way interactions, because the higher order interaction model (i.e., three-way interactions) performed no better than the two-way interaction model.

The relative importance of the predictor variables is determined and reported as part of the MARS output (Table 3). As shown, *IT Stock* was deemed the most important input variable. Year was removed from the model for lack of importance. Table 4 shows the results of ordinary least squares regression for the basis functions selected by MARS. The resulting MARS model had an R-squared value of 0.828, indicating that it has high predictive power.

The final fitted model (Table 5) resulted in eight basis functions and a constant (BF0).

Table 3. Relative importance of the input variables

Name of Variable	Variable	Cost of Omission	Importance
IT Stock	*log ITST*	0.121	100.000
Non-IT Capital	*log NITK*	0.089	72.965
Non-IT Labor	*log NITL*	0.068	49.001
Industry	*IND*	0.058	29.886
Size	*SIZE*	0.053	13.497
Year	*YR*	0.051	0.000

Table 4. Ordinary least squares results from MARS

Parameter	Coefficient	S.E.	T- Ratio	P-Value
Constant	7.257	0.051	141.693	. 999201E-15
BF3	0.557	0.030	18.522	. 999201E-15
BF4	0.178	0.024	11.416	. 999201E-15
BF6	-0.096	0.016	-5.894	. 519695E-08
BF8	-0.094	0.017	-5.514	. 450769E-07
BF10	-0.554	0.071	-7.821	. 136557E-13
BF11	0.221	0.057	3.889	. 107614E-03
BF13	0.116	0.033	3.493	. 499024E-03
BF14	0.590	0.056	10.502	. 999201E-15

F-STATISTIC = 579.494	S.E. OF REGRESSION = 0.222
P-VALUE = .999201E-15	RESIDUAL SUM OF SQUARES = 47.321
[MDF, NDF] = [8, 963]	REGRESSION SUM OF SQUARES = 227.805

Table 5. The final model—RS1 (two-way interaction)

Basis Function (BF)		Coefficient	Variable	Parent	Knot (log value)
0	BF0	7.257			
1	BF1 = max(0, *log ITST* – 6.902);				
3	BF3 = max(0, *log NITK* – 7.223);	0.557	*log NITK*		7.223 ($16.7M)
4	BF4 = (*IND= FIRE*)* BF1;	0.178	*IND*	*log ITST*	
6	BF6 = (*IND = AFF* or *Min* or *TPU* or *Con*)^3 *BF1	-0.096	*IND*	*log ITST*	
8	BF8 = (*SIZE = Large*) * BF1	-0.094	*SIZE*	*log ITST*	
10	BF10 = max(0, *log NITL* – 8.367)* BF1;	-0.554	*log NITL*	*log ITST*	8.367 ($233M)
11	BF11 = max(0, 8.367 – *log NITL*)* BF1;	0.221	*log NITL*	*log ITST*	8.367 ($233M)
13	BF13 = max(0, 9.482 – *log NITK*)* BF1;	0.116	*log NITK*	*log ITST*	9.482 ($3.034B)
14	BF14 = max(0, *log NITL* – 7.782)* BF1;	0.590	*Log NITL*	*log ITST*	7.782 ($60.5M)

Note that BF1 does not contribute directly to the model, since it does not have its own coefficient, but interacts with other basis functions. The "Parent" column depicts the variable that has interaction with the chosen predictor in the "Variable" column. Basis functions 1, 3, 10, 11, 13, and 14 are based upon numeric variables, and therefore identify "knots," or thresholds, for which a level either above or below the knot indicates significance. Since basis functions 4, 6, and 8 are based upon categorical variables, subset indicator variables (e.g., IND=FIRE) are used instead of knot values.

The knot values in the model are expressed in the log of the variable. For example, as shown in Table 4, "BF3 = max (0, *log NITK* – 7.223)."

This is interpreted as when *log NITK* is greater than 7.223 ($16.7 M), for each unit increase in *log NITK,* productivity is increased by 0.557. Since the variables are log transformed, it can be interpreted as "when *Non-IT Capital* is greater than $16.7 M, 10 fold increase in *Non-IT Capital* results in 3.61 ($=10^{0.557}$) times increase in *Value Added*." BF3 does not have a variable identified in the "Parent" column, indicating that *Non-IT Capital* acts as a stand-alone variable.

It is important to note that the results of Table 5 must be viewed in their entirety. Otherwise, one could very easily incorrectly interpret the results. In addition, pay very close attention to the coefficient values. If the sign of a coefficient of a basis function is the same as the variable in that basis function (e.g., BF3 and BF14), then the contribution is positive. However, if the corresponding signs are different (e.g., BF10, BF11, and BF13), the contribution is negative.

The fitted model shows that *IT Stock (ITST)* has one knot at 6.902 (BF1); *Non-IT Labor (NITL)* has two knots at 7.782 and 8.367 (BF10, BF11, and BF14); and *Non-IT Capital (NITK)* has two knots at 7.223 and 9.482 (BF3 and BF13). It also indicated that BF1 (related to *IT Stock*) interacts with every input variable (BF4, BF6, BF8, BF10, BF11, BF13, and BF 14) that was included in the model. As shown in the Table 5, *Non-IT Capital* is a stand-alone variable (BF3), and it may also interact with *IT Stock* (BF13). For example, BF13 is interpreted as "when *Non-IT Capital* is *less than* 9.482 ($3.034B) *and IT Stock* is *greater than* 6.902 ($7.98M), productivity *decreases by .116 for every unit increase* in BF13." The regression equation corresponding to the MARS final model can be expressed as follows:

$$\log V = 7.257 + 0.557 * BF3 + 0.178 * BF4 - 0.096 * BF6 - 0.094 * BF8 - 0.554 * F10 + 0.221 * BF11 + 0.116 * BF13 + 0.590 * BF14$$

The intercept and slope of the linear function of BF1 can be derived from the model, as shown in Appendix C.

DISCUSSION OF RESULTS

The data collected for this study was from the top 500 corporate users if IT in the United States. Therefore, the data set consisted only of large or extra large companies. It is highly probable that different basis functions would have been formulated for companies of smaller size, and hence smaller investments.

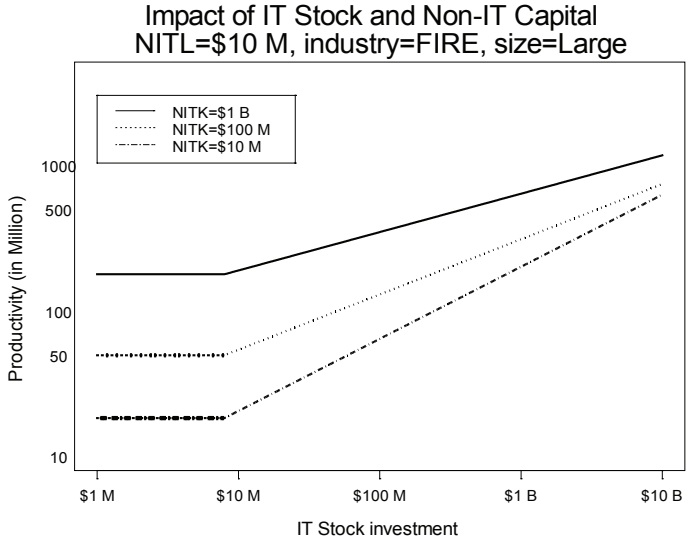
Investment in *IT Stock (ITST)*

As shown in Table 3, *IT Stock* is the most important variable for productivity (*Value Added*).

Our results indicate that *IT Stock* is not a stand-alone predictor. That is, IT investment alone does not increase the organizational productivity. Instead, *IT Stock* (in the form of BF1) interacts with every predictor variable that was included in the final model (*Industry, Size, Non-IT Labor*, and *Non-IT Capital),* and it has an impact on productivity. In addition, when it interacts with other variables, the impact of IT investment (or the slope of change) differs among industry type, size, and varying levels of non-IT investments in labor and capital. However, investment in *IT Stock* does not have a positive impact on productivity until the amount invested reaches a threshold of 6.902 ($7.98M). This is the threshold that each organization has to invest in IT in order to reap any benefit from it. Note: Only 10 companies in our sample had investments less than $7.98M in *IT Stock*.

Assuming constant *Size*, *Industry*, and investment in *Non-IT Labor*, the impact of *IT Stock* with varying *Non-IT Capital* is graphically displayed in Figure 3. As shown in Figure 3, an increase in IT Stock increases the productivity if it exceeds the threshold.

Figure 3. The impact of IT stock with the different investment levels of non-IT capital (fixing Size = Large, Non-IT Labor = $10M, and Industry = FIRE)



Investment in Non-*IT Capital (NITK)*

Non-IT Capital is a stand-alone predictor variable for increased productivity, starting at a threshold of $16.7M (7.223 log value). When *Non-IT Capital* is greater than $16.7M, and *IT Stock* is less than or equal to $7.98M (6.902 log value), productivity is increased 3.61 ($=10^{0.557}$) times for every ten-fold increase in Non-IT Capital (i.e., only BF3 is in effect). When *IT Stock* is greater than $7.98 million, the impact of *Non-IT Capital* varies, depending on the amount of *IT Stock* investment. As shown, in Table 5, when *IT Stock* is greater than $7.98M, and *Non-IT Capital* is between $16.7 M and $3.034B (9.482 log value), for every tenfold increase in *Non-IT Capital*, productivity is increased 2.76 ($=10^{0.441}$) times. Note that this is a decrease in the rate of productivity (.557 - .116 = .441).

Unless otherwise stated, a basis function is applicable to all values in the dataset. As shown in Table 5, the maximum value of log *Non-IT Capital* in our dataset is 10.812 ($64.913B). Since there are no basis functions for *log NITK* between 9.482 ($3.034B) and the maximum value of the dataset, BF3 is again applicable for values of *Non-IT Capital* between 9.482 ($3.034B) and 10.812 ($64.913B). Therefore, when *log ITST* is greater than 6.902 ($7.98M), and *Non-IT Capital* is greater than 9.482 ($3.034B), productivity again increases 3.61 times for every ten-fold increase in *Non-IT Capital*. This is also shown in Figure 3. As investment in *Non-IT Capital* increases, productivity increases also, but at a decreasing rate. The slope using *Non-IT Capital* at $1B is less than slope at $10M.

Investment in Non-*IT Labor (NITL)*

Assuming *IT Stock* is greater than $7.98M, and all other input variables are constant, when *Non-IT Labor* is between $60.5M (7.782 log value) and $233M (8.267 log value), the slope for *IT Stock* increases (i.e., BF14 and BF11) piecewise linearly. Referring back to the model, when *Non-IT Labor* is at $60.5M (7.782 log value), only BF11 is in effect, and the slope of *IT Stock* (the rate of impact on productivity) is 0.129 (i.e., (8.367-7.782)*.221). When *Non-IT Labor* is at $233 M (8.367 log value), only BF14 is in effect, and the slope is 0.345 (i.e., (8.367-7.782)*.0.590). Thus, the rate of impact

on productivity is highest when *Non-IT Labor* is in this range. Productivity remains positive for *Non-IT Labor* values greater than $233M, but at a lower rate. Thus, our findings indicate a diminishing rate of return from *Non-IT Labor* if investments in *Non-IT Labor* are beyond the optimum level.

Industry

Industry is an important predictor variable of *Value Added*, but only when acting as an interaction variable in conjunction with *IT Stock*. For every tenfold increase in *IT Stock*, when *IT Stock* is at or greater than the $7.98M threshold, the *Finance, Insurance, and Real Estate (FIRE)* industries experience a 1.51 (=10^0.178) unit increase in productivity (BF4) compared to *Man, WRT,* and *Ser* industries. Thus, IT investments from *FIRE* Industries have higher impact on productivity compared to that of other industries. Several other industries, such as *Agriculture, Forestry, and Fishing (AFF), Mining (Min), Transportation and Public Utilities (TPU), and Construction (Con),* were associated with a productivity rate of only 80% (=10^-.096) of *Man, WRT*, and *Ser (BF6).* Thus, IT investments from these industries have the lower impact on productivity, compared to that of other industries. This is also shown in Figure 4, the impact of *IT Stock* and industry on productivity. It shows the *FIRE* industries have the highest slope, followed by *Manufacturing (Man), Wholesale and Retail Trade (WRT)*, and *Services (Ser) industries,* and industries from *Agriculture, Forestry, and Fishing (AFF), Mining (Min), Transportation and Public Utilities (TPU), and Construction (Con*) have the lowest slope.

Size

Size is a significant predictor variable. As shown in Table 5, IT Investments in extra-large firms have a greater impact on productivity than that of large firms. For large firms, when investment in *IT Stock* is greater than 6.902 ($7.98 M), every tenfold increase in *IT Stock* is equal to 80% (=10^-.094) of extra-large firms' productivity rate, since its coefficient is -.094 (BF7). As with other variables, differences in size may impact productivity.

Year

Year had no impact on productivity, and was excluded by the MARS package (see Table 3). Therefore, no basis functions were formulated for *Year (YR)* in Table 5.

Figure 4. Impact of IT stock and industry on productivity (fixing L=10^7, K=10^8, and Size = Large)

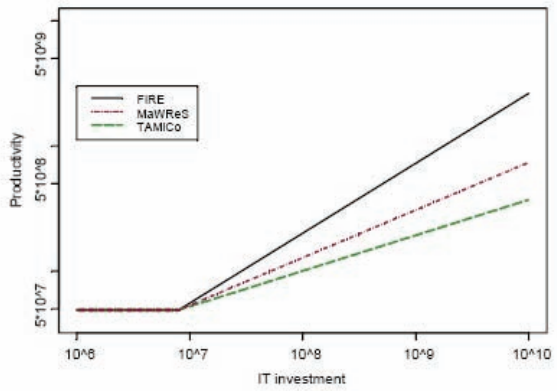
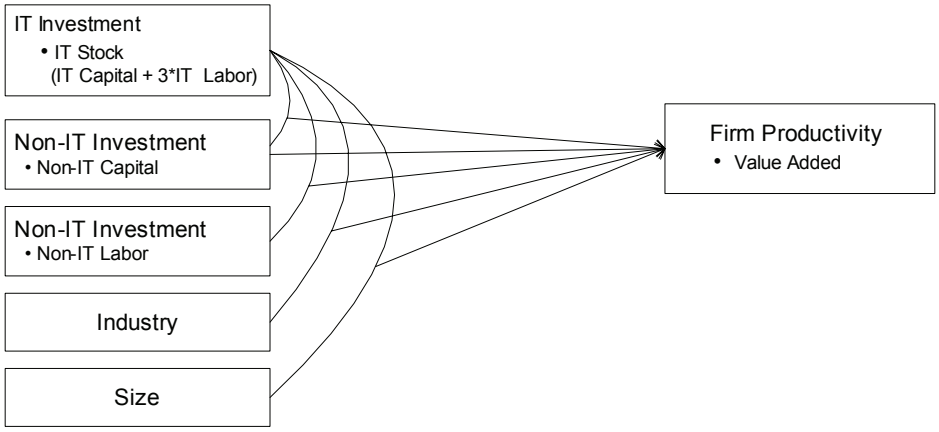


Figure 5. Final research model



Summary of Results

Based upon the discussions of our results, we summarize the following.

- Although *IT Stock* is the greatest predictor variable for productivity (*Value Added*), it is only significant as an interaction variable, combined with *Non-IT Capital, Non-IT Labor, Industry, or Size*. Thus, our study provides evidence of a relationship between IT and non-IT investments.
- *Non-IT Capital* has a significant impact on productivity, both as stand-alone, and in interaction with *IT Stock*.
- When *IT Stock* is greater than the threshold ($7.98M), and *Non-IT Labor* is greater than the threshold ($60.5M), their interaction has a positive impact on productivity.
- Extra-large companies get a better return on their IT investments than do large companies. Thus, firm size influences the overall IT impact on productivity.
- Industries in the *FIRE* have the highest return on their IT investments. As indicated, although two firms may invest the same amount in IT, the impact on productivity could be different, depending upon their industry type.

In this study, we tested five hypotheses. H1 predicts that investment in IT has a positive impact on productivity at the firm level. Our results support H1, as long as investment in IT exceeds the minimum threshold ($7.98M). The results also support H2—that there exists an interaction effect between IT and non-IT investments. The results indicate that industry (H3) and size (H4) influence the IT impact on productivity, but year (H5) does not. We therefore revised our research model (Figure 5) by removing *year*. All other variables in our original model had an impact on productivity of the firm

If we were able to manipulate the above variables and create a company that would provide us a high return on our IT investments, it would have the following characteristics:

Industry: Finance, Insurance, and Real Estate (FIRE)
Size: Extra Large
IT Stock:Invest at least $7.98M in *IT Stock*
Non-IT Capital: Invest at least $16.7M in *Non-IT Capital*

Non-IT Labor: Invest between $60.5M and $233M in *Non-IT Labor*. The slope is greatest between these values.

COMPARISON WITH EARLIER STUDIES

The results of our study suggest that the relationship between IT investments and productivity is not simply positive or negative, but rather it is much more complex than reported in previous studies. In this section, we would like to compare our results with those of previous studies by Kudyba and Diwan (2002a, 2002b) and Osei-Bryson and Ko (2004). Each of these studies used the same data source, but during different time periods. The Kudyba and Diwan (2002a, 2002b) data set covers the period from 1995 to 1997 (one year less than the current study), while the Osei-Bryson and Ko covers years 1988 to 1992. Comparison of the results from each study is shown in Table 6.

Except for the year issue, results from previous studies have been similar. However, this study shows that the relationship between investments and productivity is not linear. This provides a greater understanding of the complex relationship between IT and productivity, and therefore is a significant contribution to IS research. IT Stock (IT Capital plus three times the cost of IT labor) has the greatest impact on productivity, but it is only significant as an interaction variable. The Osei-Bryson and Ko study (2004) was able to test for a linear relationship, but not for interaction effect. They concluded that the relationship between IT investment and productivity was not linear, and that non-IT labor had the greatest impact on productivity. However, since they used the Cobb-Douglas function, they were not able to test interaction among the variables.

DISCUSSION AND CONCLUSIONS

The MARS approach, in combination with a generalized translog production function, enabled us to test the input variables both individually and in two-way interaction. Given the idiosyncrasies of IT investment, this approach provided us with greater insight into its impact on productivity of the firm.

Our work contributes to IS research in several ways. First, it evaluates the IT impact on productivity using MARS, which is a very useful tool for empirically investigating research problems in IS. Second, this study revisits the relationship between IT and organizational productivity. In this study, including contextual variables, such as industry, firm size, and year, we investigated if and how these variables influence the overall IT impact on productivity. Although a few studies have investigated IT investment using these variables, findings from these studies are mixed. This study confirms the findings of Kudyba and Diwan (2002b) that IT-intensive industries, such as FIRE industries, have the greatest impact from IT on productivity. This is different from the findings by Hu and Quan (2005). Third, unlike most previous studies, we were able to quantify the impact on productivity, based on the types of investment, size, and industry type.

Our study clearly indicates that the data are neither linear nor conforming. Thus, results suggest that the relationship between IT investment and organizational productivity is much more complex. As shown, *IT Stock* is the greatest predictor variable for productivity, but is only significant as an interaction variable. Thus, investment in IT should not be considered alone. Our study shows that IT enhances productivity at the firm level, and firms in the FIRE industries have the highest return on their IT investments.

Our study is valuable to IS researchers, because it illustrates another new approach that can be applied to IS research. It can be also very useful

Table 6. Comparison with previous IT and productivity research

Study/ Period	Methodology	Measures	Results/ Note
Osei-Bryson & Ko 2004 (1988-1992)	MARS Cobb –Douglas Production Function	Input: IT Stock, Non-IT Labor, Non-IT Capital, Year, Industry (2-digit SIC code) Output: Value Added	1. IT stock improves productivity once it exceeds the threshold 2. Can reach a point of diminishing return when over-invest in IT 3. Non-IT labor had a greater impact on productivity than did IT stock 4. Year was removed from the model Note: Interaction of variables was not tested
Kudyba & Diwan 2002a / (1995-1997)	Regression Cobb-Douglas Production Function	Input: Capital, IT Capital (or IT Flow), Labor, and IT Labor Output: Sales and Value Added	1. IT has made significant contributions to output. 2. Investments in IT increased productivity over time. Note: Interaction of variables was not tested
Kudyba & Diwan 2002b / (1995-1997)	Regression Cobb-Douglas Production Function	Input: Capital, IT Capital Labor, and IT Labor Output: Sales Revenue and Value Added	1. IT made significant contributions to output. 2. The contribution of investments in IT has increased over time. 3. higher IT-intensive industries (bank, finance, computer, & electronics) experience higher returns to IT capital Note: Interaction of variables was not tested
The current study (1994-1997)	MARS Generalized Translog Production Function	Input: IT Stock (IT Capital +3* IT Labor), Non-IT Capital, Non-IT Labor, Industry, Size, and Year Output: Value Added	1. IT is an important factor to productivity 2. IT Stock is a strong interaction variable, but a poor standalone variable when considering the impact on productivity 3. Once investment in IT Stock exceeds the threshold, increase in IT increases productivity. 4. Increase in Non-IT Capital increases productivity 5. Increase in Non-IT Labor increases productivity when both IT and Non-IT Labor exceed the minimum threshold 6. Firms in FIRE industries have the highest impact from IT on productivity 7. Size of company does matter on productivity. The largest companies have the greatest impact on productivity. 8. Year (Time) does not influence the overall IT impact on productivity. 9. IT Stock, as an interaction variable, has the greatest impact on productivity

to top managers. Findings suggest that IT alone does not impact productivity, and only when it interacts with other investments does it contribute to organizational productivity. This has important implications to managers. Although investments in IT have a positive impact on productivity, managers should know the level of IT investments to determine if it exceeds the minimum threshold before expecting any benefits from IT. If not, additional investments in IT might help increase the overall productivity. In addition, managers should be concerned, not only with investments in IT, but also investments in non-IT as well. Productivity is dependent upon different types of non-IT investments and the level of IT investments. Hence, understanding the current level of organizational investment structure is a first step toward achieving greater productivity. Although the FIRE industry has the greatest impact on IT investment and productivity, other industries such as *Agriculture, Forestry, and Fishing (AFF), Mining (Min), Transportation and Public Utilities (TPU) and Construction (Con*) can identify the current levels, and plan accordingly to achieve the greatest impact on productivity for their given industry.

Potential limitations of the study include the following. In this study, we intentionally used an older data set in order to provide some level of consistency with former studies. Firm and/or industry characteristics may have changed since that time, thus changing results. However, since the manner in which investment data is reported has changed significantly since 1997, we chose to use the older dataset. For future research, we would like to perform another study including a dataset of more recent years. Since *Information Week* changed its reporting format in 1998, the IT budget amount for each company from 1998 on needs to be estimated, based on industry average.

We are relying upon self-reported data from the *Information Week* surveys, which could lead to validity and reliability issues. However, annual financial values obtained from Compustat were generally in agreement with the survey data, and our large sample size helps to mitigate the impact of errors. Authors in previous studies reported that the overall results are not affected, due to this issue (Hitt & Brynjolfsson, 1996). However, they may limit the generalizability of the results from our research.

Another limitation could be the firm size, since the data set includes only the top 500 IT users, which represent large firms. Including smaller firms in the sample could be beneficial in understanding the true impact of firm size.

We suggest further investigating relationships between IT and Non-IT variables. We used *IT Stock* as IT investments in this study. What if we use *IT Capital* and *IT Labor* separately? Is there a relationship between the amounts invested in *IT labor* and *Non-IT Labor*? Is there a relationship between the amounts invested in *IT Capital* and *Non-IT Capital*? Is there a given ratio between any of these variables which results in the greatest productivity, and does this ratio vary, depending upon such factors as industry, or the size of the firm? Further research in these areas could possibly assist smaller companies in attaining the productivity percentages of larger companies.

ACKNOWLEDGMENT

We thank the anonymous referees for their valuable comments that significantly improved the quality of this article.

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ENDNOTES

[1] This approach was used by Kudyba and Diwan (2002a, 2002b, 2002c), which was also utilized in Lichtenberg (1995). The percentage of the hardware was chosen to capture the portion of investment that can be capitalized as IT capital. New software development, system installation, and so on are considered as part of IT Labor.

[2] Many previous studies (Brynjolfsson & Hitt, 1995; Hitt & Brynjolfsson, 1996; Kudyba & Diwan, 2002a, 2002b, 2002c; Shao & Lin, 2002) also used this as the output measure.

[3] Assume IND=TPU or AFF or Min or Con as TAMiCo.

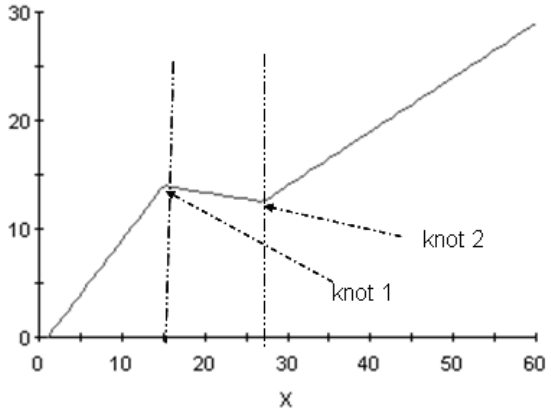
APPENDIX A

Multivariate Adaptive Regression Splines (MARS)

MARS is a data mining technique that relies upon adaptive regression splines to uncover nonlinear relationships between dependent and independent variables. Proposed by Friedman (1991), the MARS algorithm searches all possible knot locations across all variables and all interactions among all variables (Sephton, 2001). It builds a model of the relationship using splines. This enables MARS to focus on specific subregions of the data.

A regression spline function can be expressed as a linear combination of piecewise polynomial *basis functions (BF)* that are joined together smoothly at the knots. A *knot* specifies the boundary between regions. While the knots are prespecified in the classical regression spline function, the knots in MARS are selected adaptively from the data. The process of selection of knots corresponds to the selection of basis functions *(BF)*. Figure A-1 provides an example of knots, showing the relationship between one dependent and one independent variable. As shown, the relationship changes at knot 1 and knot 2.

Figure A-1. An example of knots



MARS introduces many candidate basis functions for each variable and their interactions, and selects the best possible set of basis functions in a two-phase process. In the forward phase, the model is "overfit" by adding basis functions. In the backward phase, basis functions that have the least contributions are "pruned" from the model. For a numeric variable, MARS uses the basis functions in pairs of the form $(x - t)_+$ and $(t - x)_+$ for each knot at t. The "+" represents that only positive results of the respective functions are considered; otherwise, the respective functions equate to zero. Thus, $(x - t)_+$ means $x - t$ if $x > t$, and *0* if otherwise. Basis functions for categorical variables are not assigned a threshold. Instead, it uses indicator variables. This feature enables MARS to handle combinations of numerical and categorical predictor variables in a natural way.

MARS provides ANOVA decomposition, which identifies the relative contributions of each predictor variable, as well as contributions of interactions among variables. The complexity of the relationship between the dependent and independent variable is shown by the number of basis functions used for each dependent variable.

MARS, a generalization of the classification and regression tree (CART) method and global polynomial regression, is much more flexible than both methods. It provides more interpretable results than

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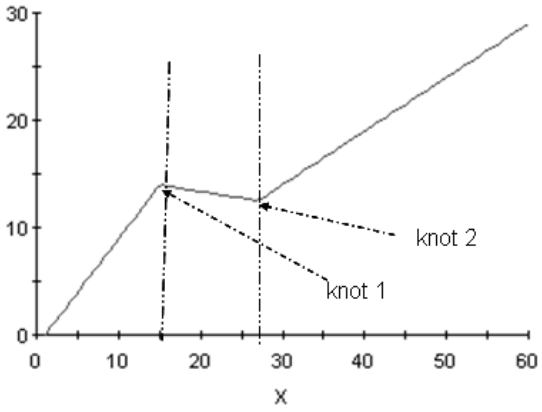

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MARS, a generalization of the classification and regression tree (CART) method and global polynomial regression, is much more flexible than both methods. It provides more interpretable results than other data mining tools, such as Neural Networks or Support Vector Machines (Hastie, Tibshirani, & Friedman, 2001).

APPENDIX B

Generalized Translog Production Function

Our generalized translog production function has the following form:

V = *f* (*NITK, NITL, ITST, SIZE, YR, IND*)

Where:

V = Value Added
NITK = Non-IT Capital
NITL = Non-IT Labor
ITST = IS Stock
SIZE = Size of the company (categorical variable - Large or Extra Large)
YR = Year of investments (categorical variable – 1994, 1995, 1996, or 1997)
IND = Industry (categorical variable – AFF, Min, Con, Man, TPU, WRT, FIRE, or Ser)

The relevant function that applies to our production function using these input variables can be estimated as the following form:

$$
\begin{aligned}
log\ V = & \beta_0 + f_{NITK}(log\ NITK) + f_{NITL}(log\ NITL) + f_{ITST}(log\ ITST) + f_{SIZE}(Size) + {}_{YR}(YR) \\
& + f_{IND}(IND) + f_{NITK\ NITL}(logNITK, log\ NITL) + f_{NITL\ ITST}(log\ NITL, logITST) \\
& + f_{ITST\ NITK}(logITST, log\ NITK) + f_{NITK\ SIZE}(log\ NITK, SIZE) + f_{NITK\ YR}(logNITK, YR) \\
& + f_{NITK\ IND}(log\ NITK, IND) + f_{NITL\ SIZE}(logNITL, SIZE) + f_{NITL\ YR}(logNITL, YR) \\
& + f_{NITL\ IND}(log\ NITL, IND) + f_{ITST\ SIZE}(log\ ITST, SIZE) + f_{ITST\ YR}(logITST, YR) \\
& + f_{ITST\ IND}(log\ ITST, IND) + f_{SIZE\ YR}(SIZE, YR) + f_{SIZE\ IND}(SIZE, IND) \\
& + f_{YR\ IND}(YR, IND) +
\end{aligned}
$$

where ε is an error term and f_x is a piecewise polynomial function for a numeric variable, and a sum of indicator functions for a categorical variable. The interaction function $f_{x,\,y}$ is obtained by sums of products of piecewise polynomials and/or indicator variables. While the translog production function uses only the numeric variables, the generalized translog production function can include both numeric and categorical variables.

APPENDIX C

MARS Final Model

The MARS Final Model shown below can be re-expressed in terms of the intercept and slope of the linear function of BF1, which represents *IT Stock*. The regression equation corresponding to the MARS model can be expressed as follows:

$$\begin{aligned} \log V = {} & 7.257 + 0.557 * BF3 + 0.178 * BF4 - 0.096 * BF6 - 0.094 * BF8 - 0.554 * F10 \\ & + 0.221 * BF11 + 0.116 * BF13 + 0.590 * BF14 \end{aligned}$$

The model can be re-expressed as:

$$\begin{aligned} \log V = {} & 7.257 + 0.557 * BF3 + 0.178 * (IND{=}FIRE) * BF1 - 0.096 * (IND{=}TAMiCo) * BF1 \\ & - 0.094 * (SIZE{=}LARGE) * BF1 - 0.554 * \max(0, \log NITL - 8.367) * BF1 \\ & + 0.221 * \max(0, 8.367 - \log NITL) * BF1 + 0.116 * \max(0, 9.482 - \log NITK) * BF1 \\ & + 0.590 * \max(0, \log NITL - 7.782) * BF1 \\ = {} & 7.257 + 0.557 * BF3 + [0.178 * (IND{=}FIRE) - 0.096 * (IND{=}TAMiCo) - 0.094 * (SIZE{=}LARGE) \\ & - 0.554 * \max(0, \log NITL - 8.367) + 0.221 * \max(0, 8.367 - \log NITL) \\ & + 0.116 * \max(0, 9.482 - \log NITK) + 0.590 * \max(0, \log NITL - 7.782)] * BF1 \end{aligned}$$

When viewed as a linear function of BF1, the term (7.257 + 0.557 * BF3) is the intercept, and the term [0.178 * (*IND=FIRE*) – 0.096 * (*IND= TAMiCo*) – 0.094 * (*SIZE=LARGE*) – 0.554 * max(0, *log NITL* – 8.367) + 0.221 * max(0, 8.367 – *log NITL*)+ 0.116 * max(0, 9.482 – *log NITK*) + 0.590 * max(0, *log NITL* – 7.782)] is the slope of BF1.

The intercept of the linear function of BF1 is a mean productivity (*Value Added*) of 7.257 ($18.1M) and *Non-IT Capital* of 7.223 ($16.7M). When *log NITK* is greater than 7.223, for each unit increase in *log NITK*, productivity increases by .557 (log value of 3.61). Thus, in this situation, productivity will be increased by 3.61 times for every tenfold increase in *Non-IT Capital*. The slope of BF1 represents the rate of *IT Stock* impact, and is dependent upon the *Industry Type, Size, Non-IT labor*, and *Non-IT Capital*.

This work was previously published in Information Resources Management Journal, Vol. 21, Issue 3, edited by M. Khosrow-Pour, pp. 1-23, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 17
Building the IT Workforce of the Future:
The Demand for More Complex, Abstract, and Strategic Knowledge

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ABSTRACT

The software development process has undergone a considerable amount of change from the early days of spaghetti code to the present state of the art of development using strategic patterns. This has caused not only changes in the toolkits that developers use, but also a change in their mindset—the way that they approach and think about software development. This study uses revealed causal mapping techniques to examine the change in mindset that occurs across the procedural to OO development transition, and lays the foundation for future studies of the OO/ pattern cognitive transition. The results indicate that there is not only increasing complexity in the cognitive maps of the OO developers, but also that there is a need for the developer to shift from routine, assembly line coding to more abstract thought processes.

INTRODUCTION

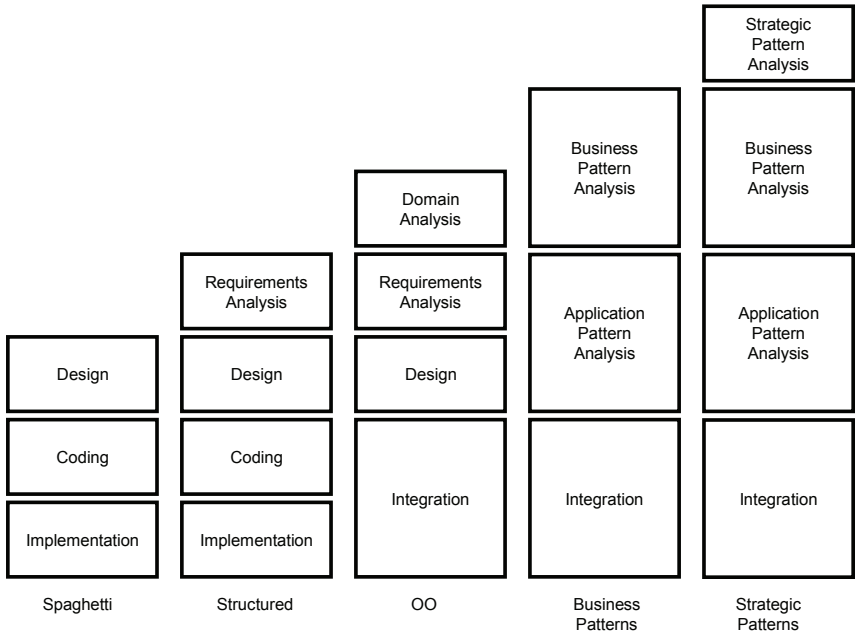
No one doubts that the software development process has undergone a profound transformation. Twenty years ago, the state of the art was the waterfall model of the systems development life cycle. The project planning and feasibility study steps were followed by systems analysis and requirements gathering, system design, coding, integration and testing, and finally installation and maintenance. The waterfall model fit very nicely within the rigid hierarchical organizational structures of the time. Functional silos and economies of scale drove software development. Systems analysts created data flow diagrams and ER diagrams and passed these to the designers. Designers would create functional decomposition diagrams and relational data models and pass these to the coders. Finally, the coders rendered all these into COBOL, FORTRAN, or a number of other procedural programming languages and database management systems. The constant translation from model to model enforced a sequence on the development process (Coad & Yourdon, 1991), with the side effect of keeping each different kind of developer in his or her place. Expert coders could not easily transition to the more abstract world of the designer and the analyst (Crowder, 1976).

The software development revolution of the 1990s began with the need for easier modeling, increased code reuse, higher quality, and easier to maintain software (Johnson, Hardgrave, & Doke, 1999). The structured programming paradigm focused on simplifying and controlling the development process (Martin & McClure, 1988) as well as increasing the efficiency and effectiveness of the development team. Where the design, code, and implementation steps of the "spaghetti code era" was replaced with a structured software engineering approach, the object oriented (OO) programming methods focus more on reuse of tested software, flexibility, and ease of maintenance with a more seamless integration of the analysis, design, and implementation development steps. This results in a development process that is incremental, concurrent, iterative, and evolutionary (Xing & Stroulia, 2005). The changes in the development process from spaghetti to structured to OO and beyond are shown in Figure 1.

The blurring of the boundaries and the smooth iteration between analysis and design in OO combined with the iterative, if not concurrent, performance of these activities has led to a cognitive blurring as well. While coders had to move to the more abstract world of analysis and design, designers had to become more analytical. Analysts, in turn, needed to move from relatively limited requirements analysis to the much more extensive domain analysis and the development of organizational information architectures (Evernden, 1996). Further, the breakdown of the barriers between the analyst and the designer and the use of models that span the lifecycle (for example, UML, Booch, Rumbaugh, & Jacobson, 1999) has created the need for more extensive project management skills. The shift from "doing analysis" then "doing design" structured by the different models in use has been replaced by an iterative and seamless development life cycle. However, just as coders have difficulty transitioning to the more abstract world of analysis, expert analysts have difficulty transitioning to the strategic world of the project planner (Nelson & Nelson, 2003).

This trend is continuing with the beginning of another software development revolution. One of the causes of recent technology project failures is the disconnect between organizational strategy and technology (Luftman & Brier, 1999; Luftman, 1996). An example of this disconnect can be found in the implementation of enterprise resource planning (ERP) systems. ERPs were sold as strategic enterprise solutions, even though at their core is a set of integrated, somewhat standardized business processes (Lee, Siau, & Hong, 2003). This approach to product development had virtually no strategic intent, and therefore ERPs, while sometimes solving process level problems,

Figure 1. The shift to the more abstract and the more strategic



often create more strategic problems than they solve (Davenport, 2000; Ezingeard & Chandler-Wilde, 1999).

The new revolution is shifting the balance of technological power from the technologists that create the technology to the managerial organizations that use technology. This revolution is creating methods for developing emerging technologies, written in a language that business decision makers understand and can control. By articulating business technology needs through understandable and consistent strategy-oriented methods (patterns), business will start to drive competitive needs down to the technologists to configure, rather than attempting to "mate" with what the technologists present to them.

A pattern-oriented development process has considerable advantages over traditional structured or OO development processes. For example, an organization encounters many problems in its day-to-day operations and in its strategic positioning against other organizations. These problems occur repeatedly in slightly different forms but with the same fundamental characteristics. A pattern is a "core of the solution" to these common problems (Alexander, Ishikawa, Silverstein, Jacobson, & Angel, 1977). Recognizing that a problem has been seen before and applying a semi-customized solution pattern to it allows faster reaction times and it "enables efficiency in both the communication and the implementation of software design, based on a common vocabulary and reference" (Adams, Koushik, Vasudeva, & Galambos, 2001).

Figure 1 shows this continuing trend. The OO revolution shifted the development process as a whole to the more abstract. The pattern revolution has again shifted the development process, first to a more organized higher-level form, then to the more strategic. While the effect on developers was well documented in the structured revolution and research is continuing on the cognitive effects of the OO revolution, the pattern-based approach to development has so far had an unknown effect on the analysts who must transition from abstract technical to abstract strategic thinking.

This article is the first step in a two-step research program that explores the cognitive differences across the OO revolution and the pattern revolution. Revealed causal mapping (RCM) techniques are used to explore how expert procedural programmers and expert OO developers exhibit expertise in their internal cognitive structures and examine the similarities and differences between the two programming paradigms. While there are general models of IS expertise (Batra, 1992; Koubek, Salvendy, Dunsmore, & LeBold, 1989; Nelson, Nadkarni, Narayanan, & Ghods, 2000), little is known about the cognitive structures of expertise that expert procedural developers and expert OO developers have and use during the software development process. Insights from this "cognitive lens" allow us to understand the differences between the two paradigms and add insight into how an individual thinks, learns, and reasons, and how his or her cognition relates to the quantity of knowledge and relationships among knowledge elements (Kraiger, Ford, & Salas, 1993). Understanding the underlying cognitive differences between the procedural and OO approaches is a first step in understanding the learning difficulties and in subsequently designing more effective relearning methods.

The second, future study examines the cognitive differences between expert OO developers and expert pattern developers to anticipate differences that may be encountered across this new revolution.

The remainder of the article is organized as follows: The second section provides an overview of prior research in software development expertise. The third section discusses the research methods used, and the fourth section provides the results. Finally, the fifth section discusses the implications of the study and suggests future areas for research.

BACKGROUND

Software development is knowledge work where the most important resource is expertise (Faraj & Sproull, 2000). There are many definitions of expertise from a cognitive perspective: the possession of a large body of knowledge and procedural skills (Bedard, 1991); an organized body of conceptual and procedural knowledge that an individual can readily access and use (Glaser & Chi, 1988); and the combination of knowledge and ability as well as the capability to use knowledge to achieve results (Nelson et al., 2000). Common to all these definitions is the idea that expertise *is a body of organized knowledge used to achieve results.* The expertise identified in this study was focused on procedural and OO software development. Procedural software development uses a set of principles in which top down design is used to develop a process-oriented, functional, modular program structure (Richardson, Butler, & Tomlinson, 1980). On the other hand, OO software development uses a set of principles where information (data) and processing (behavior) is manipulated in a manner similar to real-world objects (Brown, 1977).

The implementation phase of OO development is a cognitively incremental change from the implementation phase of procedural development (Sircar, Nerur, & Mahapatra, 2001). For example, when looking at programming in the small, an OO *method* is similar to a procedural *function*. While OO programming may appear to be simply an evolutionary development of procedural programming, it does represent a considerably different mindset for analysts (Agarwal, Sinha, & Tanniru, 1996; Boehn-Davis & Ross, 1992; Lee & Pennington, 1994). During the analysis and design phases, OO development represents a more revolutionary change from procedural development (Fichman & Kemerer, 1992; Sircar et al., 2001). The seamlessness of the models, the data-based object oriented viewpoint rather than the process-oriented viewpoint, and the shift to

more abstract thinking represents a departure from procedural programming methods. Therefore, to get a holistic picture of the differences in mindsets between procedural and OO experts, this study utilized experts in all phases of the development process rather than simply one phase.

Most studies of expertise focus on the differences between novices and experts within the same software development mindset, such as the differences between novice and expert procedural programmers. In those studies, novices typically are "true novices" with little or no previous software development experience. Novices tend to form a more concrete representation of program function during software analysis, whereas experts tend to form more abstract representations (Adelson, 1981; McKeithen, Reitman, Rueter, & Hirtle, 1981; Vitalari, 1985). As a developer becomes more experienced he or she not only stops thinking in the concrete and begins thinking in the abstract, but also develops larger and larger chunks of information to represent important functional units or structures. It appears that expertise is not just a volume of knowledge, but also a way of thinking about the problem based on how that knowledge is organized (Vitalari, 1985).

From a cognitive perspective, the chasm between the procedural and OO approaches appears vast. To successfully develop software using OO requires a divergence from the procedural approach, especially during the initial phases of development. A review of the literature suggests that a systematic identification of the major constructs of procedural and OO software development expertise and the organization of those constructs has yet to receive significant attention. The studies by Sheetz and Teagarden (Sheetz, 2002; Sheetz & Teagarden, 2001) are the only ones found that explored OO developer cognitive structures; and those focused only on specific components of the OO approach. To understand the cognitive differences between expertise in procedural development and expertise in OO development we examine three key questions:

- What are the concepts that constitute expertise in procedural and OO software development knowledge?
- How are these concepts organized into cognitive structures?
- What are the similarities and differences in cognitive representations between the two software development approaches?

The answers to these questions will increase the understanding of the structural differences in the two approaches and aid the development of effective methods for retraining expert procedural developers in the OO approach.

METHOD

The purpose of this study was to understand what knowledge expert procedural and OO software developers possess and how that knowledge was organized, in essence to understand their cognitive structures. These structures are programming language-independent and relate to the conceptual, high-level abstractions that define each mindset. In order to understand these internal cognitive structures, the individuals' external cognitive representations must be examined (Pennington, 1987). With few theories in this domain available to guide the research, an exploratory approach was deemed appropriate for this study (Nelson et al., 2000).

Causal mapping, a collection of techniques used to elicit and analyze the structure and content of cognition (Axelrod, 1976; Fiol & Huff, 1992) is a qualitative research method that is suited for capturing cognitive structures and causal assertions. To understand the expert cognitive representations, *revealed* causal mapping (RCM) (Narayanan & Fahey, 1990) was used because what was captured in the maps were the concepts and causal connections that the developer revealed during the interview. RCMs are consistent with an exploratory research setting, can be used to elicit

group level cognition (Bougon, Weick, & Binkhorst, 1977; Eden, Jones, Sims, & Smithin, 1981; Fiol & Huff, 1992; Narayanan & Fahey, 1990), and have been successfully used in a software development context (Nelson et al., 2000).

The task in this study was to elicit the relevant knowledge of expert procedural and OO software developers and cast it into appropriate structural representations. To accomplish this, expert procedural and OO software developers were identified, relevant knowledge was elicited, and the knowledge was cast into structural representations. The following sections describe this procedure.

Participants

Respondent organizations were selected based on their identification of available "expert software developers" in the procedural or OO software development approach and their willingness to participate. Over 15 organizations of various sizes (from 15 to 10,000 employees) and industries (e.g., telecommunications, manufacturing, and services) provided access to their software developers. The participants were expert procedural and OO software developers, as acknowledged by their peers using the snowball sampling technique (Shanteau, 1987, 1992).

In causal mapping research, the point of redundancy among the subjects represents the point at which further data collection would not lead to the identification of additional concepts (Axelrod, 1976). As the concepts emerge from the experts (rather than being imposed by the researchers), the point of redundancy serves to establish the adequacy of the sample. However, the point of redundancy is not calculated until after the interviews have been completed and the classification scheme has been developed. If redundancy is not reached, additional interviews are conducted. The point of redundancy was reached at 7 participants for procedural concepts and at 15 participants for the OO concepts. This indicates that the sample of 17 procedural experts and 24 OO experts was more than sufficient to capture all of the relevant concepts in the sample.

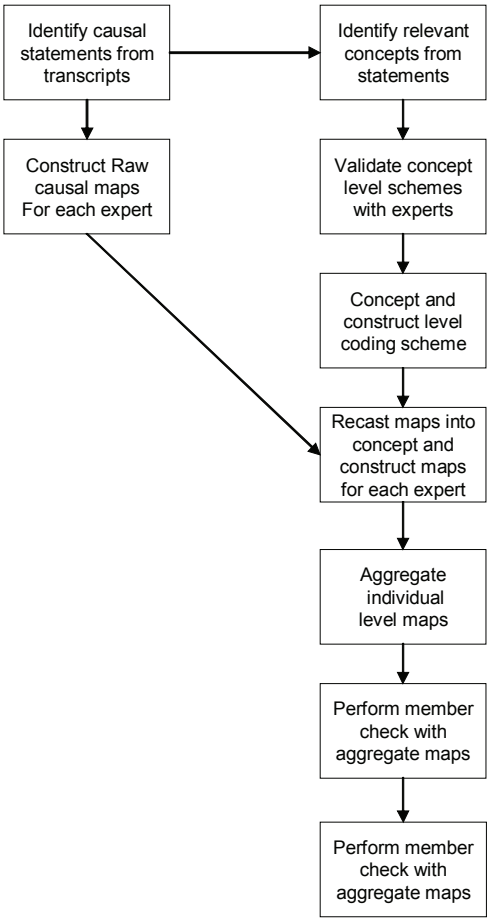
Elicitation

The interview process consisted of open-ended interviews with probes (Rossi, Wright, & Anderson, 1983) using an interview guide that was adapted from a previous study (Nelson, Armstrong, & Ghods, 2002). The guide was validated by two researchers, one with extensive revealed causal mapping experience and the other a software development expert. Each respondent was asked the same set of questions from the interview guide and included questions such as: "When a friend asks you what is object-oriented (procedural) development, what do you say?" Based on the respondent's answer to the question, follow up probes were asked to elicit further details regarding their software development thought process (e.g., "What did you think about next?"). Each interview lasted from 30 to 90 minutes. The range of interview lengths occurred because the interviewer did not constrain the responses to the questions. The interviews were transcribed into a document format ranging from 4 to 14 pages.

Deriving Revealed Causal Maps

Revealed causal mapping (RCM) (Narayanan & Fahey, 1990; Nelson et al., 2000) is a form of causal mapping, a collection of techniques used to explicate and assess the structure and content of knowledge structures (Axelrod, 1976; Fiol & Huff, 1992). Revealed causal maps provide a frame of reference for an expert's knowledge, how that knowledge is exhibited, and the reasoning behind the expert's actions. RCMs are consistent with exploratory research and have been successfully used in the software development context by Nelson, Nadkarni, Narayanan, and Ghods (2000). Figure 2 provides a flow chart of the revealed

Figure 2. Revealed causal mapping process



causal mapping process. Each phase in the process is described briefly.

Step 1: Identify causal statements. The first task is to identify the causal statements from the interview transcripts. Causal statements are statements that imply a cause-effect relationship. Some of the key words used in identifying causal statements are "if-then," "because," "so," and so forth. Consistent with Narayanan and Fahey (1990), all the statements in the form of concepts and relationships were captured in the language of the experts. To establish the reliability of the identification procedure, interview texts were coded by the primary researcher and one of the three raters who were not participants in any portion of the study. There were two rounds of coding that covered 12 interviews (six object-oriented and six procedural interview texts). Comparisons were made for agreement and disagreement between the researchers. Where disagreement occurred, the discrepancies were resolved through discussion. The reliability between the researchers was calculated by measuring the level of agreement on terms and linkages and averaged 0.80, suggesting an acceptable level of reliability.

Step 2: Construct raw causal maps. The causal statements identified in the first step were separated into causes and effects to construct the 'raw causal maps.' The Kruskal-Wallis significance test was performed to compare the causal

statements elicited for the two groups of experts (procedural and object-oriented). The two groups were determined equivalent in terms of the causal statements they produced (b= .011, df =1, p= ns). Thus the two groups could be treated similarly for coding purposes.

Step 3: Develop coding scheme. The relevant concepts are identified from the statements (Narayanan & Fahey, 1990) by grouping frequently mentioned words in the statements. A word or word group was created that captured the essence of the statement. For example, the phrase, "You group the requirements document items based on functions" was labeled 'functions'. A second researcher who also is a software development expert reviewed the statements and independently placed them into conceptual categories. The level of agreement between the raters on the conceptual categories averaged 0.81. The level of agreement was slightly higher for the object-oriented concepts than the procedural but not significantly different. Three object-oriented and one procedural expert validated the concept level scheme. Validation was accomplished by an electronic card sort. The level of agreement between the raters averaged 0.77. There were a total of 28 concepts identified (17 object-oriented and 11 procedural). A construct level classification scheme was then developed from a composite classification scheme encompassing the favorable aspects of the most appropriate schemes. The scheme was validated by a total of six individuals, three object-oriented and three procedural software development experts. The reliability between the respondents was calculated by measuring the level of agreement on the card sort. The average level of agreement was 0.70.

Step 4: Recast the 'raw' maps into revealed causal maps. The causal statements for each respondent were placed into the appropriate concept and construct level categories. The result is a concept and construct level revealed causal map for each respondent. The individual maps were then aggregated (Axelrod, 1976; Bougon et al., 1977) at the concept level and the construct level. A member check was performed using the aggregated maps to ensure accurate and comprehensive representation (Lincoln & Guba, 1985). The member check was performed at the aggregate level because the emphasis of this research study was on the mindset level. No significant modifications were made to the aggregated maps based on the member check.

Step 5: Create measures for the maps. The analysis of the maps in this study was based on past research in causal mapping (Bougon et al., 1977; Ford & Hegarty, 1984; Huff, 1990; Narayanan & Fahey, 1990). The measures used were borrowed from the social network analysis field (Knoke & Kuklinski, 1982) and include the adjacency and reachability matrices, centrality, and density measures.

An *adjacency matrix* is a matrix representing the association of direct linkages between two constructs (Knoke & Kuklinski, 1982). For this study the interest is in the presence or absence of a causal relationship between concepts and thus the adjacency matrix contains only "0's" and "1's" (Carley & Palmquist, 1992). The *reachability matrix* indicates the cumulative direct and indirect effects of a variable on all other variables and allows for a more holistic picture of the causal relationships. The reachability of each linkage is reported on the linkage between the nodes on the revealed causal map. For a detailed explanation of adjacency and reachability matrices see Nelson et al. (2000). *Density* is a characteristic of the overall map and is a measure of how connected the concepts or constructs in the map are. It is a proportion that is calculated as the number of all linkages occurring in the matrix divided by the number of all possible linkages (Knoke & Kuklinski, 1982). *Centrality* is a measure used for the individual concepts or constructs within a map. In this study, it is a measure of how central or involved the construct is to the map. Centrality is a ratio of the aggregate of linkages involving the concept/construct divided by the total linkages in

the matrix (Knoke & Kuklinski, 1982). Together these measures provide a systematic comparison of the RCMs in which all of the information contained in the map is utilized.

However, the structural measures of density, centrality, and reachability should be used with caution. While the validity of complexity and centrality have been demonstrated in an educational setting (Nadkarni & Narayanan, 2005), in causal mapping research efforts to establish the validity of the structural measures are still in the embryonic stages (Narayanan, 2005).

RESULTS

The OO and procedural software development concepts and constructs evoked in this study are shown in Table 1. The first two constructs for OO and procedural development are very much as expected. The structure construct contains foundation elements for each of the development techniques. OO development is structurally based on abstraction, encapsulation, and inheritance, generally implemented through objects, classes, attributes, and instantiation. Procedural development is structurally based on functional decomposition and interaction, implemented through functions and subroutines.

The second set of foundational constructs is behavior for OO and linear processing for procedural development. Where the structure construct captured the more static nature of the paradigms, these constructs capture their more dynamic natures. Object orientation is based on objects interacting with one another by methods passing messages. Relationships, collaboration, and polymorphism are related concepts. The pro-

Table 1. Construct level classification scheme

Object Oriented		Procedural	
Construct	**Concepts**	**Construct**	**Concepts**
Structure	Abstraction	Structure	Interaction
	Attribute		Functions
	Class		Functional Decomposition
	Encapsulation		Subroutine
	Inheritance		
	Instantiation		
	Object		
Behavior	Collaboration	Linear Processing	Linear Flow
	Message Passing		Linear Form
	Method		Linear Program
	Polymorphism		Linear Structure
	Relationship		Monolithic
OO Modeling	Identifying Objects	Functionality	Input-Process-Output
	Object Model		Data Modification
OO Development	OO Development		
	Layer		
	Patterns		

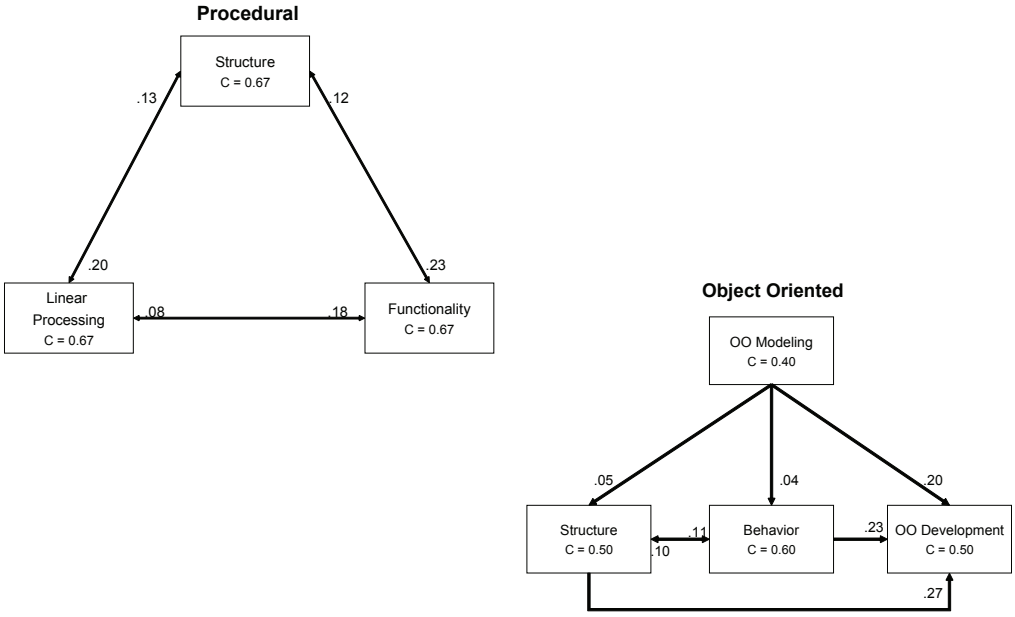
cedural paradigm generally produces monolithic structures that have a linear form and a linear flow through linear structures and linear programs. These constructs capture the dynamic differences between OO and procedural. Procedural execution is very much top-down whereas OO is much more distributed and difficult to visualize.

The final two OO constructs capture its abstract nature. OO software development is more abstract with an emphasis on modeling: creating an object model by identifying objects. Development proceeds in layers, identifying and implementing patterns. Procedural development is much more concrete and focuses on functionality by modifying data through processes modeled as input—process—output structures.

Figure 3 shows the revealed causal maps for procedural and OO software development expertise. The centrality of each construct was equal (0.67) indicating that there was no central construct, and that all three constructs were all equally important to procedural software development. The aggregated RCM is fully connected has a density of 1.00, which indicates that experts saw strong connections between all of the constructs. The procedural constructs are intertwined with each other and are difficult to separate. There is no exclusive "cause" or "effect" construct, with all three being both causes and effects. The reachability ranged from 0.08 to 0.23 with a fairly equal reachability distribution.

The aggregated construct level RCM for OO constructs is very different from the procedural RCM. OO software development expertise was defined by four constructs: structure, behavior, OO modeling, and OO development. The majority of concepts in two constructs (structure and behavior) correspond to extant literature of OO software development, which suggests that the key concepts of OO include: abstraction, class, encapsulation, inheritance, message passing, method, object, and polymorphism. The structure construct focuses on the mechanisms that support the class/object structure and has a centrality of

Figure 3. Revealed causal maps



0.50 and the behavior construct has a centrality of 0.60. Combined with the OO development construct with a centrality of 0.50, these three constructs occupy a central role in OO development. The OO modeling construct has a slightly smaller centrality of 0.40 suggesting a lesser role in OO software development. The importance of the OO development construct, its underlying concepts, and its connection to the foundational OO constructs (structure and behavior) has not been noted previously and is the focus of future research.

While the range of centrality measures was not large (0.40 – 0.60) the difference does underscore the differences in the roles that the constructs are assigned in OO development. This contributes to the complexity of learning OO development because developers not only need to learn the OO concepts but also where the different concepts fit into the OO development mindset. The density of the OO map was 0.83 indicating a high interconnectedness of constructs, which adds to the complexity of OO development.

In addition to complexity, the aggregated RCM reveals that experts saw OO modeling/analysis as a cause construct (all arrows originate from the construct) and OO development concepts as an effect construct (all arrows terminate into the construct). The structure and behavior constructs were mixed (both cause and effect constructs). The OO modeling/analysis (cause) construct was comprised of trigger concepts (e.g., identifying objects), that instigate the OO development process and trigger the use of other concepts. The OO development concepts (effect) construct was comprised of result concepts (e.g., OO development) that do not cause any further action. The structure and behavior constructs were mixed (both cause and effect) thus indicating the iterative nature of OO development in which both structure and behavior play key roles on an ongoing basis.

The OO map reachability values ranges from 0.04 to 0.27. The weakest connection was from OO modeling/analysis to behavior, and the strongest from structure to OO development concepts. There was a mutual connection between the structure and behavior constructs but the strongest reachability occurs for the linkages in which OO development concepts was the effect construct.

Object-Oriented vs. Procedural

The OO approach was slower to reach redundancy than the procedural approach. This result could be attributed to the OO approach being less parsimonious than the procedural approach, or perhaps the more complex nature of OO (Shanteau, 1987). The content (similarity of concepts) was the next comparative measure. While there was some carryover of concepts from procedural to OO (e.g., abstraction), the procedural developers in this study did not address these as concepts associated with procedural development. There was negligible overlap in the concepts elicited for each approach. The cognitive distance between the two approaches appears to be significant, thus increasing the cognitive load on the developer making the transition to the OO approach (Morris, Speier, & Hoffer, 1999).

The OO map was more centralized with a hierarchical structure. In this study, it was found that the OO approach emphasized behavior (including concepts such as methods, message passing, and polymorphism) as a central theme (centrality 0.60). This is consistent with the definition of OO software development provided earlier. also It was also found that the OO development concepts and structure constructs had the next highest centrality (0.50). The centrality of the structure construct was consistent with the definition of OO and the concepts involved (e.g., object, class, encapsulation) were central to the approach. An interesting finding was that the centrality of the OO development concepts (e.g., layer) was higher than the centrality of the OO modeling/analysis construct (e.g., identifying objects). The OO modeling/analysis construct was expected to be more central because one “difference” between

procedural and OO software development is how you think about the problem (Nelson et al., 2002). It appears that the different "approach" aspect was captured in the OO development concepts construct. As one developer stated,

It took me a while to stop thinking linearly or procedurally and start looking at the things. Once I did that, started seeing the things, then I knew I was doing OO…. The biggest problem with the switch to OO is people that know procedural development are thinking in processes not objects.

In contrast to the OO map, the procedural constructs were all centrally placed (centrality 0.67). Thus, while the OO map was hierarchical with regard to the differences in centrality of the constructs, the procedural map was flat. This is not to say that the procedural concepts were of less importance, but that the program structure, program functionality, and linear processing nature of procedural development were so central to the essence of procedural development, it was difficult for the experts to cognitively separate them.

Looking at the connections between the constructs, the procedural map was perfectly dense (1.00) and the OO map was less dense (0.83), indicating the OO approach was more disconnected and compartmentalized. The procedural map was completely connected with all constructs, both causes and effects. With the OO map there was only one mutual arrow (arrow with two heads) between the structure and behavior constructs with the remaining connections having unilateral arrows (arrowhead with one head). The structure and behavior constructs were both causes and effects, which speaks to the interconnected nature of the OO approach. In contrast, the OO modeling/analysis construct was a cause construct only and OO development concepts was an effect construct only. Again, with OO modeling/analysis starting the development process it made sense that it would drive the remaining constructs. Similarly, the finding that the OO Development Concepts construct was a "result" of the OO development process is consistent with the emphasis of the construct on the system level aspects of development.

The last point of comparison was the elaboration of constructs. The higher elaboration of constructs for the OO approach (4.3 versus 3.7) indicated a slightly higher degree of chunking surrounding the constructs. Chunking occurs when a series of actions or grouping of concepts is abstracted into a conceptual chunk (e.g., Adelson, 1981). It appears that the OO developers abstracted more concepts into a chunk that the procedural developers.

DISCUSSION

The practice of software development is changing. The very early "spaghetti code" era gave way to the more disciplined structured/procedural development paradigm based on the process model: input—process—output. As the environment changed, this paradigm shifted to a more continuous, seamless development environment. This new paradigm emphasizes abstraction and modeling and deemphasizes the more linear processes of coding. This study examined the cognitive representations of expertise in both OO and procedural software development. When individuals think about developing software in these two paradigms, not only is the knowledge content different between procedural and OO development, but the structure and organization of that knowledge is also different.

The results of this study (the concepts, constructs, and their cognitive structure) provide a starting point for empirically representing the knowledge structure of expertise for each approach and for extrapolating the knowledge structures required as the next, strategic, revolution begins to take shape. The correspondence of the empirically evoked concepts to the theoretical constructs of procedural software development suggests that the RCM technique has empirical

validity in the task of knowledge representation. On the other hand, the RCM technique not only uncovered concepts identified by extant OO literature such as encapsulation and object, but added important concepts to our understanding of OO expertise with the possible extension to patterns.

The representation of procedural and OO software development expertise contributes new constructs and concepts to the body of literature within the OO mindset. The concepts identified in this research not previously discussed as essential to OO development were patterns, layer, and OO development. Patterns are defined as collection of objects or classes that function in a certain way and can be reused with other projects (Johnson, 1997; Shull, Lanubile, & Basili, 2000). Layer is defined as the process of building a system in stages. The emphasis on "development" has not been previously captured as a focus of the OO mindset. The OO development concept evoked in this study acknowledges the importance of this cognitive focus. These concepts not previously identified as fundamental to the OO approach add to the understanding of OO development within the context of the larger system. While these contribute to the understanding of OO development, further research is needed to validate these new concepts and constructs before generalizations can be made.

In addition to theoretical contributions, several practical implications can be drawn from this study. Organizations switching to the OO approach need developers to put the new techniques into practice. One solution to this problem is to hire external OO developers, but while universities are turning out new employees who know OO programming, hiring these programmers is not an optimal solution because they do not possess the business domain knowledge that is necessary for successful OO development. A more workable solution is to retrain existing developers in the OO approach.

The results of this study show some of the difficulties and confusion that expert procedural programmers have when transitioning to OO development. For example, Table 1 shows the constructs and concepts discovered in interviews with expert OO and procedural developers. At the lowest, "programming in the small" level, the two mindsets are really quite similar and it is easy to transition from one to the other.

On the surface, the structure of the OO mindset is familiar to the procedural developer. Classes, objects, encapsulation, instantiation, and attributes are all familiar concepts and are all discovered through the process of functional decomposition and the identification of subroutines and the associated data that the subroutines operates upon. Data was not addressed as a procedural concept, primarily due to the clear data/process split in the procedural mindset. Data in the form of objects and classes is a fundamental part of the OO mindset so it is not surprising that it appears as a structural OO concept.

Moving on to the second part of programming in the small, the OO behavior and the procedural linear processing constructs are also similar on the surface. However, this is where the OO/procedural mindsets begin to differ. To those who see OO as an evolution of procedural development, message passing, methods, collaboration, and relationships are really no different than the linear programming, form, and flow of procedural functions and subroutines. However, the revealed causal map shows that the expert OO developers see OO structure and OO behavior as very different than expert procedural developers see procedural structure and procedural linear processing. OO structure and behavior are both effects of OO modeling with all three leading to OO development. Procedural causal maps have structure, linear processing, and functionality, all tightly related and connected.

The difference between the procedural and OO approaches is substantial. Clearly, not only

the concepts used in these two approaches are different, but the cognitive organization of these concepts is also different. This is consistent with the arguments of some (Agarwal et al., 1996; Boehn-Davis & Ross, 1992; Fichman & Kemerer, 1992; Lee & Pennington, 1994) that at the conceptual phase of software development, the transition from procedural to OO represents a radical change. The transition to OO software development requires not merely a shift in tools and techniques, but also a fundamental shift in the way developers think about IS problems and solutions.

The combination of the revealed causal maps and the construct/concept table indicate that the OO mindset is truly a shift in thinking and not an extension of procedural development. The practical implications to this leads to the suggestion that the best method for transitioning programmers is a deep immersion into OO theory followed by a practical application of the OO language rather than trying to develop the OO theory by learning and then practicing the OO extensions to the language. For example, learning C then adding on the C++ extensions. While the transition works structurally in the small, this will interfere with learning the more abstract OO modeling and OO development constructs.

LIMITATIONS AND FUTURE RESEARCH

Although using practicing experts as respondents enhances the relevance of the results, external validity of the study is somewhat limited due to the sample size and snowball sampling technique utilized. The snowball sampling method is a non-probability method and consequently there is a potential for sample bias. Familiarity bias results from the person who is known to more people having a higher probability of being mentioned than the person known only to a few others (Sudman, 1976). This bias was minimized for this project because software development professionals were asked to identify others in their area with expertise (Abdolmohammadi & Shanteau, 1992). Thus selection was based on acknowledged expertise and not familiarity. Future research employing large samples is required to validate, refute, or modify the maps developed in this study. One potential limitation of the study was the use of retrospective recall in the data collection. During the interviews the developers were asked to think of their most recent software development experience as a reference for the questions. With any retrospective recall there is always a chance of inaccurate recall, but as acknowledged experts were used and the experts in the study completed an average of almost seven OO projects and 51 procedural projects, their recollections should provide an accurate reflection of expert conceptual knowledge.

The greater layering (complexity) of the OO approach map, one of the pieces of evidence unearthed by this study, suggests that the procedural and OO approach require very different mindsets. An alternate explanation is that the differences in complexity may be partly due to the differences in maturity of the software development approaches. While there are differences in the maturity of both mindsets, the OO approach has been in existence since the early 1960s. Perhaps the lack of maturity is a function of the complexity and not vice versa. Another possible explanation is that the findings were merely a function of the sample. As with any sample, there is a potential for bias. While the participants were experts as acknowledged by their peers, perhaps their expertise was insufficient to adequately capture the essential OO/procedural concepts. Although this is possible, it is not very likely because of the point of redundancy achieved for each sample was well below the number of experts interviewed. The list of concepts for each approach was exhausted well before the last participant was reached.

One of the first avenues for future research is replication with a large sample study. The cogni-

tive structures of procedural and OO development expertise could be tested against the cognitive structures of a large sample of software developers. Another avenue for research would be to survey individuals who are expert OO software developers with no procedural experience. An analysis of their cognitive structures would not only be interesting but also would affirm or rebut the findings of this research. At this time, there are no expert OO software developers without any procedural experience, but perhaps in the future this avenue will be available. A third avenue for future research could include the retraining of expert procedural software developers. A laboratory experiment could be conducted in which retraining based on the constructs and linkages found in this study is tested against traditional retraining techniques.

This is the first part of a two part study. Future research will examine the cognitive structures of expert strategic, pattern-based software developers to determine how their mindsets differ from expert OO developers. It may be expected that the transition from abstract to strategic thinking will be just as difficult as the transition from procedural to abstract thinking.

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This work was previously published in Information Resources Management Journal, Vol. 21, Issue 2, edited by M. Khosrow-Pour, pp. 63-79, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 18
Perception Gaps about Skills Requirement for Entry-Level IS Professionals between Recruiters and Students:
An Exploratory Study

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ABSTRACT

Dramatic changes in the U.S. economic situations and offshore outsourcing trends in the IT (Information Technology) industry have affected the IS (Information Systems) job market and recruiters with regard to IS knowledge/skills that their new hires should possess. Keeping pace with these changes presents a challenge for IS recruiters and students. There is an urgent need for a study that investigates the perception gaps between IS recruiters and students about the knowledge/skill sets required for a new entry-level IS hire. This study reports the findings from a survey of IS recruiters and IS students in the U.S., detailing the differences of their understanding about the knowledge/skills requirement.

INTRODUCTION

It gets more difficult to specify and prepare for the skills demanded by the profession in advance of beginning work activities (Barley & Orr, 1998; Mirvis & Hall, 1996). The rate of skill and technology change, and the number of factors from which the changes arise are increasing (Weick, 1990). Contemporary job roles require a significant amount of work activity that is contingent and hard to predict (Darrah, 1994). In accordance with this trend, an IS professional shows skill deficiency in various areas (Koh, Lee, Yen, & Havelka, 2001; Lee, Koh, Yen, & Tang, 2002; Lee, Trauth, & Farwell, 1995; Nelson, 1991; Trauth, Farwell, & Lee, 1993). IS Professionals are continuously adding, replacing, and retrofitting their expertise to ensure an adequate stock of knowledge and

work skills (Adler, 1992; Carnevale, Gainer, & Shultz, 1994). IS professionals understand that they need to keep their skills up to date. But doing so requires knowing what skill sets are in demand (Prabhakar, Litecky, & Arnett, 2005).

The graduate of an IS program should possess the required skills and training to perform well at an entry-level position and to have a basis for continued career growth as a professional (Couger, Davis, Dologite, Feinstein, Gorgone, & Jenkins, 1995). However, the gaps (from a moderate to a very serious level) between knowledge/skills that are taught in academia and those that are demanded by the IS industry have been reported by researchers (Lee et al., 2002; Lee et al., 1995; Nelson, 1991; Young & Lee, 1996).

The evolution of IS technology is the major cause of the dilemma confronting educators and managers as they try to prepare students or to recruit workers for the changing IT environment (Clark, Greer, & Maier, 2002). As technologies continue to change, university IS programs interested in continuous improvement and serving their students must repeatedly revise their curricula to remain current and relevant. The academic curricula changes are often constrained by available credit hour limitations (Braun, Crable, & Tesch, 2003) and lack of resources. Academic institutions are also asked to turn out IT graduates with a very wide range of skills, while there are severe pressures to cut costs and constrain curricula (Van Der Vyver & Lane, 2006).

Moreover, an IS recruiter tends to seek individuals with the ability to integrate their technical knowledge with other managerial skills such as communication, interpersonal, and organizational skills (Koh, Lee, & Tang, 2000/2001). An IS professional needs to possess and improve nontechnical skills (Dawn, Dinesh, Medlin, & Vannoy, 2001) to cope with the industry demand.

Recent developments in IS industry jobs and career paths have made it more difficult to ascertain the knowledge/skills required of an IS professional (Martinsons & Cheung, 2001). There are a variety of IS career paths, each of which may require somewhat different skill sets. Even within the same career path, IS practitioners are required to have different knowledge and skills as their careers progress (Koh et al., 2001). As a discipline, IS is always changing, with rapid advances in technology, shifting job descriptions, and an increasing number of diverse factors which affect job success in the field. Additionally, shifting industry patterns, intense competition, outsourcing, and rapid globalization are blurring both job requirements and which skills are in demand (Lee & Lee, 2006).

Since the end of the dot-com boom, time has been rough for IS professionals (Malykhina, 2004; Smith, 2004). According to Forrester Research, offshore outsourcing as a percentage of IT budgets rose from 12% in 2000, to 28% in 2003. This outsourcing trend influences the required skill sets for domestic IS students. The U.S. Bureau of Labor Statistics estimates that there are now 212,000 unemployed computer and mathematics professionals (Keefe, 2003). IS educators should feel the necessity of preparing their students for this adverse job market. In a relatively weak job market, keeping an eye on the skills demanded is increasingly important (Prabhakar et al., 2005).

Given the aforementioned changes and problems, the most current knowledge/skill sets required for entry level IS professionals in today's dynamic and competitive business environment need to be identified. In addition, the potential perception gaps between recruiters and students about skills required need to be investigated. The recognition of the gaps motivates students and faculty to adjust their skill sets and curricula design. Students and faculty know they must keep their knowledge and skills, as well as curricula, up to date, but doing so requires knowing what skills are in demand.

To gain a better understanding about the important skills and knowledge needed to succeed in today's business environment, a survey study was proposed in 2003. The objectives of the

study were to: (1) assess recruiters' and students' perceptions of the important knowledge and skill sets for entry-level IS professionals; (2) identify and investigate any perception gaps that may exist between the two groups.

For the purpose of this study, an IS professional is considered to be a person whose main tasks are to develop information systems, to maintain them, or to help people use them within an organization. An IS student is considered to be a college student who majors in MIS (Management Information Systems) in the business school.

A comparative investigation was made between the above two groups based on the following two areas. In the first, the broad spectrum of knowledge/skills required for an entry-level IS professional was investigated. In the second, the specific software tools that an entry-level IS practitioner uses to do his/her everyday jobs were analyzed and compared. The authors believe that the findings in this study can provide IS students, academics, and practitioners with useful information to pinpoint the perception gaps between the two groups about the knowledge and skills that are most important for an entry-level IS professional. The findings of this study can help academic institutions create better curricula to fit the changing demands of the job market, and can help students be better prepared for their IS careers.

BACKGROUND OF THE STUDY MEASURES

Various classifications of the abilities, knowledge, and skills which an IS graduate must possess have been suggested (Ashenhurst, 1972; Couger et al., 1995; Lee et al., 1995; Nelson, 1991; Todd, McKeen, & Gallupe, 1995; Young & Lee, 1997). Despite the absence of a universally accepted classification, the literature generally agrees that people regard personal/interpersonal skills as more important than "IS-related" skills (Lee et al., 2002; Lee et al., 1995; Leitheiser, 1992). This is true even for entry-level IS personnel (Young & Lee, 1996).

In some research, however, technical expertise is viewed as very important in finding an internship. Young and Lee (1996) found that the level of technical expertise often determines an IS major's access to an internship, which may directly result in permanent hiring after the internship. Todd et al. (1995) also found that recruiters put more emphasis on technical knowledge than on business or systems knowledge when they recruit IS personnel. Koh et al. (2001) found a transition in IS skills requirements based on progressive work experience: most first-time hires start with technical jobs, and then move to jobs requiring more "nontechnical" responsibilities as their careers develop.

The ACM curriculum planning recommendations on IS education were developed over decades based on a taxonomy of knowledge content classified according to IS technology, IS process, and AACSB Common Body of Knowledge (on business management). There is, however, no generally accepted classification of IS knowledge/skills, or a consensus on which knowledge/skills are more critical than others.

Due to the lack of a common classification taxonomy and terminology, the authors had to rely on sample question items from several sources and on the authors' understanding of key emerging technologies in this field in order to construct the survey instrument. The emphasis has been placed on finding the skills required for an entry-level IS professional.

Critical IS Knowledge/Skills Used in the Study

The broad spectrum of knowledge is classified according to the breadth of context in which the knowledge is applied, based on the prior studies (Koh, et al., 2001; Lee et al., 2002; Lee et al., 1995; Young & Lee, 1996). The broad spectrum of critical IS requirements are classified into

four categories: core IS knowledge (managerial and technical), knowledge about organizational/industrial entities, interpersonal skills, and personal skills.

Core IS knowledge denotes the knowledge that differentiates IS personnel from others in an organization. This category is divided further into two subcategories: IS managerial knowledge, and IS technical skills. The IS managerial subcategory corresponds to the knowledge required of an IS manager, such as understanding IT trends, IT vision, and IT industry (Lee et al., 2002). The IS technical subcategory corresponds to the technical specialties an IS manager needs to perform a task successfully.

Interpersonal skills denote the skills required to work well in an organization or on a team. IS practitioners should be able to think critically and creatively about technical and managerial issues relating to the design and use of IT in solving business problems, rather than possessing mere knowledge about a narrow subject (Dalal, 1994). Clearly, "creative thinking" and "critical thinking" skills, in addition to personal motivation, are important personal traits valuable to IS practitioners.

Organizational knowledge includes the understanding of a business functional area, a company, and a general business industry (Lee et al., 2002; Nelson, 1991).

In the second part of the study, the software tools that an entry-level IS employee needs to perform his/her everyday jobs are scrutinized in detail. We made a list of widely used software tools, and from this, extrapolated 20 needed software skills. Recent developments in IS technology, such as data warehouse/mart, Web production (both publication and interactive Web programming), Enterprise Resource Planning (ERP), and so on are included in the software tools list (Table 3). To improve the reflection of the most current perceptions regarding critical IS knowledge/skills, the questionnaire was further refined through three pilot tests.

METHODOLOGY

In addition to the questions about demographic information on the subjects of the study, both survey instruments (one for recruiters, and the other for students) consisted of 43 questions about perceived knowledge and skills required for entry-level IS professionals. 21 questions relate to the required knowledge/skills, and the other 22 questions relate to specific software knowledge. The 43 questions were primarily based on those used in an empirical study in Lee et al. (2002). Some questions were modified in the pilot study. The two survey instruments are included in Appendices A and B.

Three IS professionals pilot-tested the survey instrument used by recruiters; corresponding modifications were made based on their feedback. For recruiters' data, a random sample of 500 was selected from D&B's North American Million Dollar Database. This database provides the information professional, marketer, and sales executive with data on approximately 1,600,000 U.S. and Canadian leading public and private businesses. Company entries include industry information with up to 24 individual eight-digit SICs, size (number of employees and annual sales), type of ownership, principal executives, and biographies.

The questionnaires were sent to the IS/IT recruiters working in the IS/IT department in those 500 companies. The aforementioned recruiters are actually IS professionals, based on the fact that they were employees in IS/IT department for the organizations. In the first round of survey, 38 respondents sent the questionnaires back. In the follow-up survey sent to nonrespondents, 13 subjects returned the survey. A total of 51 valid responses were collected, corresponding to a 10.2% response rate.

For the students' survey instrument, five MIS students participated in the pilot test in the fall of 2002. Based on their feedback, the authors—with the assistance of three statisticians—refined the questionnaire. Some of the demographic questions

had been used in an empirical study by Fang, Lee, Lee, and Huang (2004).

Senior students from three AACSB-accredited business schools were participants in this empirical study during the spring of 2003. Two schools are in the state of Ohio (one is in an urban area, and the other in a rural area). The third school is located in a metropolitan area in Tennessee. 725 seniors were informed about the survey in the three schools (115, 245, and 365 respectively). 365 seniors participated in the survey (67 and 134 students from the two Ohio schools, and 164 students from the school in Tennessee).

The primary focus of the MIS programs in the three schools is on the undergraduate degree program. The undergraduate program curricula and requirements are fairly similar. Each school received AACSB accreditation many years ago. The majority of the MIS students in these three schools started job searches in the fall of year 2002. At the time of the survey (May 2003), the students' job search duration was about 10 months. Each MIS program actively encourages students to take MIS internships, although internships are not required, and students do not receive course credits for their internships. The majority of the internships are paid internships.

DISCUSSION

We used two types of data analysis—rankings based on mean values of variables, and multivariate analysis of variance—to investigate the statistical relationships between IS recruiter and IS student data. For simplicity, variables with the following p-values are marked in Tables 1 and 3 *: for *P*-value <0.001; **: for *P*-value <0.05; ***: for *P*-value >0.05.

Demographics of Employer Profile

The majority (80%) of the sample subjects held managerial positions (53% management, and 27% senior management). This data is in line with our expectations since we surveyed managers in the recruiting area of companies. The majority (77%) of the sample subjects worked in the position for less than 10 years (53% less than 5 years, and 24% 5–10 years). Most sample subjects (97%) had post-secondary education degrees, 73% undergraduate, and 24% graduate degrees. 53% were males, and 45% were females. Respondents' ages were somewhat evenly distributed between 20 and 50. The numbers of employees in each company are widely distributed between less than 100, and more than 10,000. The majority (60%) of the respondents' companies employed more than 1000. About 25% of the respondents said their companies had 100–499 employees.

Although many respondents (35%) report that their company revenue is greater than one billion dollars, 32% reported income of less than 100 million dollars. Various types of industry employers were surveyed, ranging from IT, manufacturing, and financial, to the health care industry. The three largest types of industries surveyed were manufacturing (27%), financial (18%), and IT consulting (14%). Recruiters responded optimistically about the job market next year. 17% said the job market will be better, and 51% said that the job market will stay the same. No responses predicted a market decline.

It is very interesting to note that 19 respondents reported that they did not hire any females, while only 2 respondents said all their new hires are females. Most of the respondents' firms report that females account for less than 50% of their new hires. Similarly, 20% of the firms in the survey hired people of color, and only two respondents reported that all their new hires are people of color. Most of the respondents' firms report that people of color account for less than 50% of their new hires.

About three-fourths of the respondents said that less than 50% of new hires had MIS internships, while about one-fourth said that more than 50% of new hires had internship experience. Included in

the one-fourth group are eight respondents whose firms' new hires had MIS internships. A significant number (86%) of the respondents agree that MIS internships help MIS students receive full-time MIS entry-level positions. 41% responded positively, and 47% were neutral as to whether double majors help MIS students receive full-time MIS entry-level positions. 30% disagree that early major declaration is advantageous in receiving a full-time job position, while the majority (57%) of the respondents are neutral.

Demographics of MIS Student Participants

Demographic backgrounds were solicited in the questionnaire. Student participation in the 2003 survey was anonymous. 365 students participated; 53% of the subjects were male, and 47% were female. 66% had a single major (MIS); 27% had double majors; 6% had three majors. Among those with double or triple majors, the percentages corresponding to non-MIS majors were 82% marketing, 17% finance, and 1% accounting. 60% of the participants declared their MIS majors in the first two years of college, while 39% did so during the last two years of college (1% did not respond). 52% reported that they did not have an MIS internship experience. 31% of the participants had one MIS internship, and 13% had more than one MIS internship experience (4% did not respond). The aforementioned statistics, such as MIS internship percentages, may not be generalized to other schools, because the three universities in this study were not randomly selected.

General Knowledge/Skills for an Entry-Level IS Employee

In order to investigate the general knowledge and skills in more detail, the following skill sets were included in the questionnaire. All skill sets were categorized by four major areas: core IS knowledge and skills (both managerial and technical), organizational knowledge, interpersonal skills, and personal skills/traits. The results are tabulated in Table 1 below. The skills are arranged in descending order of recruiters' rankings. Items with significant differences (five or more in relative rank differences) are marked in bold for detailed investigation. It should again be noted that the knowledge/skills sets surveyed in the study are primarily targeted for an entry-level IS professional. The authors expect different outcomes for experienced professionals, as the skill sets required change with the work experience (Lee et al., 2002).

It is very interesting to note that both recruiters and students rated the interpersonal and personal skills/traits—such as team skills, communication skills, critical/creative thinking skills, and personal motivation—as the most important attributes for a new entry-level IS employee. This finding is not different than that of the prior study (Young & Lee, 1997). It is even more interesting that these interpersonal/personal attributes are rated higher than any others, such as IS core knowledge and technical skills, as required skills sets for an entry-level IS professional. As IT becomes ubiquitous, and outsourcing is getting popular in most of the industries, it is not uncommon for IT professionals to work in a multiculture and across-discipline environment. Interacting with overseas clients, as well as suppliers and colleagues from different countries, is no longer unusual in today's global business settings. Thus, interpersonal and personal skills and traits are becoming more and more imperative.

Significant perception gaps are found in almost every question item. The averages of student data are consistently lower than those of recruiters. Students view the knowledge/skills as less important than recruiters view them. These differences are statistically significant, with *P*-value less than 0.001, except for one item: vision about the IS/IT competitive advantage. The implication of the aforementioned findings is that the bar has

been raised, and employers expect a lot. They require a blend of technical, business, and people skills, combined with the right attitude. One of the reasons might be that many IT jobs are being moved offshore, particularly to China and India, where there are many highly skilled IT professionals who can be hired with relatively low cost. Due to the existence of a world marketplace for IS/IT employment (Weber, 2004), more and more organizations are even now seeking to employ IS/IT workers who have international experience.

Based on the relative ranking system, significant perception gaps are also found in several areas. Recruiters rated implementation, operation, and maintenance issues (e.g., documentation) as 6th most important, whereas students rated them as unimportant, with the relative ranking of 16th. Significant difference is shown in the rankings of general business environment knowledge (e.g., economics, legal). Recruiters view it as the 10th most important requirement, but students rate it as 17th. There is a similar result with object-oriented methodologies; recruiters rank the skill relatively more important than the students do.

Reversed results are found in the perceived importance of network/communication software/program languages, knowledge of specific organizations (e.g., your company), and vision of the IS/IT competitive advantage. Students view them as relatively more important than recruiters do, although the actual averages of students are still lower than those of recruiters. Authors found

Table 1. General knowledge, skills, and personal attributes for an entry-level IS employee

Recruiters			Students	
AVG	Rank	Most wanted skills/knowledge/personal attributes for entry-level IS employees	Rank	AVG
4.81	1	Team skills (e.g., ability to work as part of a project group)*	3	3.56
4.78	2	Communication skills (oral and written)*	1	3.62
4.77	3	Critical thinking skills (ability to analyze and evaluate)*	4	3.52
4.72	4	Personal motivation*	2	3.57
4.57	5	Creative thinking skills (e.g., ability to generate new ideas)*	5	3.39
4.13	6	Implementation, operation, and maintenance issues (e.g., documentation)*	16	2.83
4.12	7	Operating systems (e.g., Windows2000/XP/NT, UNIX, Novell)*	7	3.21
4.09	8	Packaged software (e.g., spreadsheet, word processing)*	6	3.36
4.02	9	Awareness of IS technology trends*	8	3.15
3.8	10	Database design/development*	9	3.06
3.78	11	Knowledge of general bus. environment (e.g., economic, legal)*	17	2.79
3.78	12	Web Development programming languages*	14	2.91
3.76	13	Object-oriented methodologies*	18	2.64
3.71	14	Knowledge of specific business functional areas (e.g., finance, marketing)*	15	2.9
3.67	15	Hardware concepts (PCs/Server/Routers/Network)*	12	2.98
3.64	16	Network/communication software/program languages*	10	3.04
3.54	17	Knowledge of specific organizations (e.g., your company)*	11	3.03
3.53	18	SDLC (Systems Dev. Life Cycle) methodologies*	19	2.51
3.44	19	Visions about IS/IT competitive advantage***	13	2.97
3.23	20	Programming languages (high level, 3 rd GL such as COBOL)*	20	2.27
3.22	21	Knowledge of specific industries (e.g., retail, automobile, computers)*	21	2.17

****Statistically not significant; P-value > 0.05.*

Table 2. Averages based on categories

Highest Category Average: Interpersonal Skills:

Recr.		Stud.
4.81	Team skills (e.g., ability to work as part of a project group)	3.56
4.78	Communication skills (oral and written)	3.62
4.80	Category Average	3.59

2nd Highest Category Average: Personal Skills/Traits:

4.77	Critical thinking skills (ability to analyze and evaluate)	3.52
4.72	Personal motivation	3.57
4.57	Creative thinking skills (e.g., ability to generate new ideas)	3.39
4.69	Category Average	3.49

3rd Highest Category Average: Core IS Skills:

4.13	Implementation, operation, and maintenance issues (e.g., documentation)	2.83
4.12	Operating systems (e.g., Windows2000/XP/NT, UNIX, Novell)	3.21
4.09	Packaged software (e.g., spreadsheet, word processing)	3.36
4.02	Awareness of IS technology trends	3.15
3.8	Database design/development	3.06
3.78	Web Development programming languages	2.91
3.76	Object-oriented methodologies	2.64
3.67	Hardware concepts (PCs/Server/Routers/Network)	2.98
3.64	Network/communication software/program languages	3.04
3.53	SDLC (Systems Dev. Life Cycle) methodologies	2.51
3.44	Visions about IS/IT competitive advantage	2.97
3.23	Programming languages (high level, 3 rd GL such as COBOL)	2.27
3.77	Category Average	2.91

4th Highest (Lowest) Category Average: Organizational knowledge:

3.78	Knowledge of general business environment (e.g., economic, legal)	2.79
3.71	Knowledge of specific business functional areas (e.g., finance, marketing)	2.90
3.54	Knowledge of specific organizations (e.g., your company)	3.03
3.22	Knowledge of specific industries (e.g., retail, automobile, computers)	2.17
3.56	Category Average	2.72

little difference in the relative rankings of other question items than those discussed above.

In a categorical analysis (Table 2), the interpersonal skills category was rated as the most important category, followed by the personal skills/traits, the core IS skills, and last, the organizational knowledge categories. Both recruiters and students view the relative importance of the categories in the same way. It is interesting to note that both the interpersonal and personal

Table 3. Specific software knowledge/skills for Entry-level IS employees

Recruiters			Students	
AVG	Rank	Most wanted software knowledge for entry-level IS employees	Rank	AVG
4.22	1	Internet/Navigation Browsers (e.g., MS Explorer)*	1	3.18
4.20	2	Interactive Web Programming Languages (e.g. ASP, .NET, JAVA)*	4	3.08
4.04	3	Electronic Mail Tools (e-mail software)*	2	3.17
4.04	3	Database Query Languages (e.g., SQL)*	6	3.04
4.02	4	PC Operating Systems (e.g., Win NT/2000/XP, Linux)*	2	3.17
3.96	5	Word Processing Tools (e.g., Word, WordPerfect)*	5	3.07
3.90	6	Web Publication Languages (e.g., HTML)*	3	3.12
3.86	7	Spreadsheet Tools (e.g., Excel)*	7	3.02
3.81	8	Client-Server Database Tools (e.g., Oracle)*	8	3.01
3.71	9	Personal Database Tools (e.g., MS Access)*	10	2.87
3.56	10	Object-Oriented Languages (e.g., C++, SmallTalk)*	13	2.65
3.55	11	Data Warehouse/Data Mart Tools*	14	2.61
3.43	12	Presentation Tools (e.g., PowerPoint)***	9	2.99
3.41	13	Project Management Tools (e.g., MS Project)*	11	2.68
3.36	14	Mini/Mainframe Operating System (e.g., VMS, UNIX)*	15	2.60
3.26	15	CASE Tools (e.g., Oracle Designer, MS Visio, etc.)*	12	2.66
3.17	16	Enterprise Resource Planning Tools [ERP (e.g., SAP)]*	16	2.54
3.02	17	High Level Procedural Languages (e.g., COBOL)*	18	2.18
2.74	18	Simulation/Optimization Tools (e.g. Pro Model, Simons)*	20	2.08
2.72	19	Statistics Tools (e.g., SAS, SPSS, and Minitab)*	19	2.09
2.67	20	Expert Systems/Shells [ES (e.g. GURU and Visual Expert)]*	17	2.30
3.55		Total Average		??

****Statistically not significant; P-value > 0.05.*

category averages were rated much higher than the other two category averages, core IS skills, and organizational knowledge.

Specific Software Program Skills for an Entry-level MIS Employee

Questions about the following software program types (Table 3) were included in the questionnaire. The results are arranged in descending order of rankings by recruiters, and the results were then compared to the rankings by students.

Significant perception gaps are found in almost every question item. The averages of students' data are consistently lower than those of recruiters. Students view the software skills as less important than recruiters view them. These differences are statistically significant (*P*-value less than 0.001), except one item: presentation tools. The potential explanation is that employers are more demanding than the students would expect in the current job market. The bar is also raised regarding specific software skills for entry level IS hires. The aforementioned finding is also in line with the findings in Gallivan, Truex, and Kvasny (2004), which identified that employers continue to specify more technical skills per hire.

Recruiters rated Web-related tools, such as Internet/Web browsers and interactive Web programming software, as the first and the second most important software skills; they were ranked third and sixteenth respectively in the prior study (Koh et al., 2001). Students rated the same tools as the first and the fourth most important tools, respectively. Students rated the e-mail tools 2nd highest. In the current global business environment, Web-enabled functionality is almost a necessary part of most of the IS applications. Due to the rapid development of the Web technology and its increased popularity, Web-related tools and programming software are becoming vital. The study (Prabhakar et al., 2005) also found the increased importance of the Web-related IS skills, such as Web programming, dot net development, and Java.

Both recruiters and students rated Database query language, such as SQL, with relatively high rankings, 3rd and 6th respectively. It is interesting to note that personal productivity tools—such as Electronic mail, PC operating systems, and Word processing—are rated relatively higher than IS specialty tools, such as database, programming language, project management, and CASE tools by both groups. Further investigation is needed to understand this finding. A conceivable interpretation is that some of the skills, such as project management skills and CASE tool-related skills, cannot be taught effectively in the classroom that can hardly replicate the environment of a real IS project.

One of the emerging software packages, ERP (Enterprise Resource Planning), is rated relatively low (16th) by both recruiters and students. Authors presume that individual companies may provide the necessary education and training for that skill, although this finding may need further investigation as well. High-level procedural languages, simulation/optimization tools, statistics tools, and expert systems (ES) are rated as the lowest by both groups.

CONCLUSION

There are significant perception gaps between IS recruiters and IS students in terms of what knowledge/skills are more important than others. Perception gaps exist in almost every knowledge/skills and software question item in the survey instrument. Students ranked all knowledge/skills consistently as less important than recruiters ranked them.

Interesting information is found by comparing the two groups' data, based on a categorical analysis and relative rankings of each item. Both recruiters and students have similar perceptions about the importance of some category skills, compared to others. Both view all of the interpersonal/personal items—such as team skills, communication skills, critical thinking skills, personal motivation, and creative thinking skills—as the most important skill sets for new entry-level IS employees. More interestingly, both groups rate the interpersonal/personal category skills above any other category of skills, such as core IS knowledge/skills and organizational knowledge.

Considering that the IS curriculum has been developed based on IS core knowledge/skills, this finding offers the motivation for IS educators to emphasize communication and interpersonal/personal skills within the framework of applying IS knowledge and skill. As the IS knowledge is acquired and applied, communication and interpersonal /personal skills should not be ignored.

Based on a relative-ranking type analysis, both IS recruiters and students rate Web-based software skills and personal productivity software skills as more important than the traditional programming/development skills, such as high-level and object-oriented programming skills. Both groups rated other development-related software skills, such as project management and CASE, below interpersonal/personal skills. Simulation, statistics, and expert system skills are rated lowest by both groups.

Although further investigation is needed in several areas, the findings of the study can provide IS students, academicians, and practitioners with information about the most desired knowledge/software skills for entry-level IS hires, and also help all parties understand the significant perception gaps existing between them. Compared to the students' expectations, employers are demanding more, not just in terms of the depth, but also the mix of the skills and knowledge. Students are expected to be well-rounded in business and technical areas, along with the interpersonal skills and the right attitude. Universities may need to do more to adjust their curricula, such as strongly advocating internships, or even the international program participation. While offering courses focusing on the fundamentals, universities may need to provide students with courses that are vocational in nature. Consequently, students can gain knowledge and skill sets, as well as experience with current IS phenomena.

Limitation of the Study

This study is not without its limitations. The study can be strengthened by increasing the sample size. Although the authors received responses from 51 companies, the number (51 of 500) may not be adequate to be representative of the entire IS industry. Another component of the representativeness is nonresponse bias. As nonresponse increases, the potential for a biased sample increase. This means that the obtained responses of a probability sample might no longer be representative of the larger population. The response bias could exist in the responses received. The response bias might affect the sample in such a way that the corresponding findings based on the sample have much less external validity. In short, nonresponse bias could reduce a probability sample to what is essentially a convenience sample, and consequently, the conclusions are less generalizable to the entire IS industry.

For future study, authors plan to increase the response rate, and consequently narrow the bias-adjusted confidence intervals and facilitate generalizing the statistical analysis results to the whole IS industry. Moreover, there could be a number of explanations for something as fundamental as "importance." Whether a skill is important is open to interpretation by IS students and IS recruiters. As a result, some of the findings in this study might not clearly discover the true attitudes of some survey respondents. For future study, the in-depth interviews of students and recruiters are needed to truly discover these attitudes, and then to use appropriate anchor labels on the response categories on the survey questionnaire.

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APPENDIX A

Survey on Critical Factors Influencing MIS/IT Job Placement and Required Skills for an Entry-level MIS/IT Professional

Part I (#1-15) Employer profile. Please provide the following background information about you and your company.

Your Position:
☐ senior management ☐ middle management ☐ non-management
Years in Position:
☐ less than 5 ☐ 5-9 ☐ 10-19 ☐ 20-29 ☐ more than 30
Education:
☐ high school ☐ undergraduate degree ☐ graduate degree
Gender:
☐ male ☐ female
Age:
☐ under 20 ☐ 20-29 ☐ 30-39 ☐ 40-49 ☐ 50-59
☐ over 60

Your Company
Number of Employees:
☐ less than 100 ☐ 100-499 ☐ 500-999 ☐ 1000-4999 ☐ 5000-9999
☐ more than 10,000
Gross Revenue ($/Million):
☐ less than 50,☐ 50-99, ☐ 100-199, ☐ 200-499, ☐ 500-999,
☐ more than 1B

1. To which type of industry does your firm belong?
☐ IT Consulting firms (Big Four: Accenture, Cap Gemini, Deloitte Touche, and PWC)
☐ IT Consulting firms (other than Big Four firms)
☐ Computer technology vendors (e.g., Microsoft, Oracle, Cisco, Dell)
☐ Manufacturing firms (e.g., General Electric, Proctor & Gamble)
☐ Retail firms (e.g., Kroger, Federated Dept. Stores)
☐ Financial firms (e.g., banks, investment, insurance)
☐ Health Care related firms
☐ Delivery service related firm
☐ Other (please specify):_____

2. Compared to this year's job market in MIS, what is your opinion about next year's job market?

☐ Much Worse
☐ Worse
☐ Same
☐ Better
☐ Much better

3. For this year, approximately what percentage of the new hires (full-time MIS entry-level positions) in your organization are female?

Percentage: _____%

4. For this year, approximately what percentage of the new hires (full-time MIS entry-level positions) in your organization are people of color?

Percentage: _____%

5. For this year, approximately what percent of the new hires (full-time MIS entry-level positions) in your organization are students who once had MIS internships?

Percentage: _____%

6. Do you agree that MIS internships help MIS students receive full time MIS entry-level positions?

Strongly disagree		Neutral		Strongly agree

7.. Do you agree that double majors (MIS major plus another major) helps MIS students receive full-time MIS entry-level positions?

Strongly disagree		Neutral		Strongly agree

8. Do you agree that declaring a major in MIS in the first two years of college is better than declaring an MIS major in the last two years of college, in terms of receiving full-time MIS entry-level positions?

Strongly disagree		Neutral		Strongly agree

9. Do you agree that a high overall GPA helps MIS students receive full time MIS entry-level positions?

Strongly disagree		Neutral		Strongly agree

10. Do you agree that a high MIS GPA helps MIS students receive full time MIS entry-level posi-tions?

Strongly disagree		Neutral		Strongly agree

11. Which qualification do you believe is the most important in your decision to hire a full-time MIS entry-level job candidate? (Please select only one.)

☐ Communication skills
☐ High overall GPA
☐ High MIS GPA
☐ Intern work experience
☐ Management Skills
☐ Recommendations
☐ Technical skills
☐ Other (please specify):_____

12. Which qualification do you believe is the most important in your decision to hire an MIS internship candidate? (Please select only one.)

☐ Communication skills
☐ High overall GPA
☐ High MIS GPA
☐ Intern work experience
☐ Management Skills
☐ Recommendations
☐ Technical skills
☐ Other (please specify):_____

13. Which source does your company normally use to locate potential applicants for its entry-level MIS positions?

☐ School's career planning office
☐ Internship fair
☐ Internet
☐ Newspapers
☐ MIS department office
☐ Relatives/Friends
☐ Instructors' recommendations
☐ Other (please specify):_____

14. In which area does your organization most need new MIS full-time entry-level employees?

☐ Systems analysis and design
☐ Clerical/data entry
☐ Database area
☐ IT help desk
☐ Networking
☐ Programming
☐ Web design and development
☐ Other (please specify):_____

15. Which average salary range does your company offer for full time MIS entry-level positions this year?

☐ Less than $30,000
☐ $30,000-34,999
☐ $35,000-39,999
☐ $40,000-44,999
☐ $45,000-49,999
☐ $50,000-54,999
☐ More than $55,000

(If the salary offered is above $55,000, please specify: $_____)

☐ Undecided

Part II (#16-58): Required Knowledge/Skills for Entry-Level MIS Professionals.

Please indicate how important it is for an entry-level MIS professional in your company to possess the specific job knowledge, skills, and personal attributes listed below**.**

16. Hardware concepts (PCs/Server/Routers/Network)

Unimportant		Neutral		Very Important

17. Packaged software (e.g., spreadsheet, word processing)

Unimportant		Neutral		Very Important

18. Operating systems (e.g., Windows2000/XP/NT, UNIX, Novell)

Unimportant		Neutral		Very Important

19. Network/communication software/program languages

Unimportant		Neutral		Very Important

20. Database design/development

Unimportant		Neutral		Very Important

21. Programming languages (high level, 3 rd GL such as COBOL)

Unimportant		Neutral		Very Important

22. Web Development programming languages

Unimportant		Neutral		Very Important

23. SDLC (Systems Dev. Life Cycle) methodologies

Unimportant		Neutral		Very Important

24. Object-oriented methodologies

Unimportant		Neutral		Very Important

25. Implementation, operation, and maintenance issues (e.g., documentation)

Unimportant		Neutral		Very Important

26. Visions about IS/IT competitive advantage

Unimportant		Neutral		Very Important

27. Awareness of IS technology trends

Unimportant		Neutral		Very Important

28. Knowledge of specific business functional areas (e.g., finance, marketing, production)

Unimportant		Neutral		Very Important

29. Knowledge of specific industries (e.g., retail, automobile, computers, textile)

Unimportant		Neutral		Very Important

30. Knowledge of specific organizations (e.g., your company, your host company)

Unimportant		Neutral		Very Important

31. Knowledge of general business environment (e.g., economic, legal)

Unimportant		Neutral		Very Important

32. Team skills (e.g., ability to work as part of a project group)

Unimportant		Neutral		Very Important

33. Communication skills (oral and written)

Unimportant		Neutral		Very Important

34. Personal motivation

Unimportant		Neutral		Very Important

35. Creative thinking skills (e.g., ability to generate new ideas)

Unimportant		Neutral		Very Important

36. Critical thinking skills (ability to analyze and evaluate)

Unimportant		Neutral		Very Important

Part III. (#37-58) Please rate the importance of specific software knowledge for a new entry-level MIS employee.

37. Spreadsheet Tools (e.g., Excel)

Unimportant		Neutral		Very Important

38. Word Processing Tools (e.g., Word, WordPerfect)

Unimportant		Neutral		Very Important

39. Presentation Tools (e.g., PowerPoint)

Unimportant		Neutral		Very Important

40. Personal Database Tools (e.g., MS Access)

Unimportant		Neutral		Very Important

41. Client-Server Database Tools (e.g., Oracle)

Unimportant		Neutral		Very Important

42. Data Warehouse/Data Mart Tools

Unimportant		Neutral		Very Important

43. Enterprise Resource Planning Tools (e.g., SAP)

Unimportant		Neutral		Very Important

44. Project Management Tools (e.g., MS Project)

Unimportant		Neutral		Very Important

45. Expert Systems/Shells (e.g. GURU and Visual Expert)

Unimportant		Neutral		Very Important

46. Simulation/Optimization Tools (e.g. Pro Model, Simons)

Unimportant		Neutral		Very Important

47. Statistics Tools (e.g., SAS, SPSS, and Minitab)

Unimportant		Neutral		Very Important

48. High Level Procedural Languages (e.g., COBOL)

Unimportant		Neutral		Very Important

49. Object-Oriented Languages (e.g., C++, SmallTalk)

Unimportant		Neutral		Very Important

50. Database Query Languages (e.g., SQL)

Unimportant		Neutral		Very Important

51. CASE Tools (e.g., Oracle Designer, MS Visio, etc.)

Unimportant		Neutral		Very Important

52. Internet/Navigation Browsers (e.g., MS Explorer)

Unimportant		Neutral		Very Important

53. Web Publication Languages (e.g., HTML)

Unimportant		Neutral		Very Important

54. Interactive Web Programming Languages (e.g., JAVA, XML)

Unimportant		Neutral		Very Important

55. Electronic Mail Tools (e.g., Lotus Notes, Microsoft Outlook)

Unimportant		Neutral		Very Important

56. Teleconference/Video-conference Tools

Unimportant		Neutral		Very Important

57. PC Operating Systems (e.g., Win NT/2000/XP, Linux)

Unimportant		Neutral		Very Important

58. Mini/Mainframe Operating System (e.g., VMS, UNIX)

Unimportant		Neutral		Very Important

THANK YOU for your participation in this survey.

APPENDIX B

MIS Student Survey

The objective of this survey is to investigate the factors that have impact on students' full-time job offers in the field of Management Information Systems (MIS). This survey consists of two parts: 1) questions (#1-26) about the internship and job offer, and 2) questions (#27-69) about your perception on the required MIS skill/knowledge set for an entry-level MIS professional. Please fill your answers on the computer answer sheet provided. **Please leave identity section, such as name, birth date, id number, special codes of the answer sheet, blank**. Your personal information will be kept confidential. The result of this survey will be shared later. Thank you for your cooperation.

Part I (Question 1-26): Internship Opportunity and Job Offer

1. What is your primary major?
   a. MIS
   b. Majors other than MIS in the business school
   c. Non-Business major

2. What is your gender?
   a. Male
   b. Female

3. How many majors do you intend to complete?
   a. 1
   b. 2
   c. 3
   d. 4 or more

4. You can skip this question if you have a single major in MIS.
If you have a major(s) other than MIS, select other major(s):
   a. Accounting
   b. Marketing
   c. Finance
   d. Decision Science/Management Science
   e. Economics
   f. Organization Behavior
   g. Management (Production/Operation/Human Resource)
   h. Not business (then specify)_____

5. When did you declare your major in MIS?
   a. Freshman
   b. Sophomore
   c. Junior
   d. Senior

6. When is your expected graduation time?
   a. Spring 2003
   b. Summer 2003
   c. Fall 2003
   d. Spring 2004
   e. Summer 2004

7. What is your opinion about the next year's job market in MIS, compared to this year's market?
   a. Much Worse
   b. Worse
   c. Same
   d. Better
   e. Much better

8. What factor do you believe is the most important in finding an MIS related full-time job? (Please select only one)
   a. Communication skill
   b. High GPA
   c. Intern work experience
   d. Management Skill
   e. Recommendation
   f. Technical skill
   g. Other (please specify:)

9. What factor do you believe is the most important in finding an MIS internship? (Please select only one)
   a. Communication skill
   b. High GPA
   c. Intern work experience
   d. Management Skill
   e. Recommendation
   f. Technical skill
   g. Other (please specify:)

10. What is your current overall GPA (considering all the courses taken so far)
   a. My GPA is >=3.5
   b. >=3.0 and <3.5
   c. >=2.5 and <3.0
   d. My GPA is <2.5

11. What is your current GPA in MIS?
   a. My GPA is >=3.5
   b. >=3.0 and <3.5
   c. >=2.5 and <3.0
   d. MY GPA is <2.5

12. For approximately how many MIS related internships have you applied?
    a. 1 to 2
    b. 3 to 4
    c. 5 to 6
    d. 7 to 8
    e. 9 to 10
    f. More than 10

    If you never had any MIS related internship, please go to question 20

13. How many MIS related internships have you had so far?
    a. 1
    b. 2
    c. 3
    d. 4

14. From which source did you find your most recent MIS related internship?
    a. School's career planning office
    b. Internship fair
    c. Internet search
    d. MIS department office
    a. Relatives/Friends
    b. Instructors' recommendation

    Other (please specify:)

15. What is the nature of your most recent MIS related internship?
    a. Systems analysis and design
    b. Clerical/data entry
    c. Database
    d. IT help desk
    e. Networking
    f. Programming
    g. Web design and development

    Other (please specify:)

16. In which type of firms/industry did you have your most recent MIS related internship?
    a. IT Consulting firms (Big 4: Accenture, Cap Gemini, Deloitte Touche, and PWC)
    b. IT Consulting firms (other than Big 4 firms)
    c. Computer technology vendors (e.g., Microsoft, Oracle, Cisco, Dell, etc.)
    d. Manufacturing firms (e.g., General Electric, Proctor & Gamble)
    e. Retail firms (e.g., Groceries, department/discount stores, etc.)
    f. Financial firms (e.g., banks, investment, insurance, etc.)
    g. Health Care related firms
    h. Delivery service related firms

    Other (please specify:)

17. To what extent, does your MIS related internship(s) help you perform in MIS courses?
    a. No help at all
    b. A little help
    c. Some help
    d. A great amount of help

18. To what extent, does your MIS course work help you perform in MIS related internship(s)?
    a. No help at all
    b. A little help
    c. Some help
    d. A great amount of help

19. How much did you receive for your most recent MIS internship?
    (Please approximate hourly wage if paid a lump sum)
    a. $10 per hour or below
    b. $11-13 per hour
    c. $14-16 per hour
    d. $17-19 per hour
    e. $20-22 per hour
    f. 23 dollars per hour or more
    Others (please specify:)

20. To how many companies have you applied for MIS related full-time positions?
    a. 1 to 2
    b. 3 to 4
    c. 5 to 6
    d. 7 to 8
    e. 9 to 10
    f. More than 10

21. About how many first round job interviews (MIS related) have you had?
    a. 1 to 2
    b. 3 to 4
    c. 5 to 6
    d. 7 to 8
    e. 9 to 10
    f. More than 10

If you have not received any MIS related full-time job offers yet, please go to question 27 on page 7.

22. How many MIS related full-time job offers have you received?
    a. 1
    b. 2
    c. 3
    d. 4
    e. More than 4

23. What is the nature of the MIS related full-time job offer you have received (If more than one job offers, please describe the one you will take)?
    b. Systems analysis and design
    c. Clerical / data entry
    d. Database
    e. Help desk
    f. Programming
    g. Networking
    h. Web design/development
    Other (please specify:)

24. Does your job offer come from a company where you had MIS related internship (If you have more than one job offers, use the one that you will take to answer this question)?
    a. Yes
    b. No

25. In what type of firms/industry do you receive your MIS related full-time job offer (If you have more than one job offers, use the one that you will take to answer this question)?
    a. IT Consulting firms (Big 4: Accenture, Cap Gemini, Deloitte Touche, and PWC)
    b. IT Consulting firms (other than Big 4 consulting firms)
    c. Computer technology vendors (e.g., Microsoft, Oracle, Cisco, Dell, etc.)
    d. Manufacturing firms (e.g., General Electric, Proctor & Gamble, International Paper)
    e. Retail firms (e.g., Groceries, department/discount stores, etc.)
    f. Financial firms (e.g., banks, investment, insurance, etc.)
    g. Health Care related firms
    h. Delivery service related firms
    Other (please specify:)

26. Please select the salary range for the MIS related full-time job offer you received (if you have more than one job offers, select the range based on the job offer you will take).
    a. Below 30, 000
    b. 30, 000-34,999
    c. $35,000-39,999
    d. $40,000-44,999
    e. $45,000-49,999
    f. $50,000-$54,999
    g. Over $55,000
    h. Undecided

    (If you're the salary offered is above $55,000, please specify: $)

Please go to next page for answering questions on part II.

Part II (#27-69): A Required Skill/Knowledge Set for MIS Professionals

In order to perform his/her task professionally and successfully, an IS professional is expected to possess the following set of knowledge/skills (or subjects of knowledge/skills) and personal traits. For each category, **please rate how important you think it is for an entry-level MIS professional.**

Note: The questions (27-69) are the same as the questions (16-58) in the questionnaire used by recruiters in Appendix A.

This work was previously published in the Information Resources Management Journal, Vol. 21, Issue 1, edited by M. Khosrow-Pour, pp. 39-63, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 19
The Relationship Between the Fulfillment of the IT Professional's Psychological Contract and their Organizational Citizenship and Innovative Work Behaviors

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ABSTRACT

Little is known about the relationship between of the level of fulfillment of the IT professional's psychological contract and their innovative work and organizational citizenship behaviors. Using psychological contract and social information processing theories, this study proposes to answer the research question: What is the relationship between the level of fulfillment of the IT professionals' psychological contract and their organizational citizenship and innovative work behaviors? Survey data were collected from 209 IT professionals using group-administered paper and on-line surveys. Results show positive relationships with the level of fulfillment of the IT professional's psychological contract and their innovative work behavior, as well as four of their organizational citizenship behaviors, specifically loyalty, advocacy participation, obedience, and functional participation. Extending the body of knowledge, the dimensional approach of the psychological contract was used resulting in the scope, focus, and tangibility dimensions being the most significant predictors of the organizational behaviors.

DOI: 10.4018/978-1-60566-962-5.ch019

INTRODUCTION

Management continues to view information technology (IT) professionals as human capital, and use this resource to maximize organizational effectiveness, enhance performance, and maximize organizational goals, all while perhaps cutting IT costs (Josefek Jr. & Kauffman, 2003). In coordination with these strategic goals, IT departments are expected to be leaner, yet remain multi-talented and innovative (Koch, 2006). Pring (2003) calls attention to the fact that organizations still need innovation and value delivered from their IT professionals, even when organizations are focusing on cost management issues, such as IT service providers. And while organizational effectiveness is affected by the productivity and performance of employees, there are other work behaviors beyond the dependable role performance that are also sought after by management. Two such extra-role behaviors are innovative work and organizational citizenship.

Research and practitioner literature stress the importance of innovation and organizational citizenship in IT professionals. While an IT professional's job may have an implicit degree of creativity and innovation required, organizations may have difficulty monitoring creativity and innovation objectively. Koch (2006) states that IT departments continue to need IT professionals who have not only in-depth technology knowledge, but can also create new products and capabilities. Innovative work may also be an acknowledged element to the job, as evidenced by one IT professional who was quoted saying, "…it's all about solving problems of the business…and there's always something new to learn" (Murphy, 2005). According to CIO Magazine, even when organizations are faced with cost cutting mandates, chief information officers (CIO) are still charged with emphasizing innovation and creating competitive advantage (Varon, 2005). In fact, 65 percent of the CIOs surveyed believe that "bringing ideas for IT-enabled business innovation to the table is a significant or dominant aspect of their roles" (Varon, 2005).

Organizational citizenship continues to be seen as a vital component to organizational effectiveness. Podsakoff, Whiting, Podsakoff, and Blume (2009) found organizational citizenship behaviors (OCB) is related to a variety of organizational-level outcomes including productivity, efficiency, reduced costs, customer satisfaction, and turnover. In Ang and Slaughter's (2001) research specific to IT professionals, contract workers exhibit lower extra-role (citizenship) behaviors than permanent systems developers, and supervisors evaluate a contract workers loyalty and obedience lower than permanent systems developers. Moore and Love (2005) find differences by job category, in that levels of organizational citizenship behaviors are lower in the IT employees than the employees from work areas other than IT.

The current IT job market complicates this situation as organizations consider management strategies to keep their IT professionals engaged, productive, appreciated, and on the job, or lose them to another company (McGee, 2005; Motti, 2006). The psychological contract, the employee-employer relationship with respect to perceived obligations to each, has been theorized to unite the employee with their organization and regulate their behaviors (Robinson, Kraatz, & Rousseau, 1994). One online poll found that 69 percent of the IT professionals surveyed were looking for a new employment position, and the number one reason given was that they did not like the current employers' management or culture (McGee, 2005). Research shows that when the employee's psychological contract is breached or violated, it can lower job satisfaction (Robinson & Rousseau, 1994), organizational commitment (Coyle-Shapiro & Kessler, 2002; Suazo, Turnley, & Mai-Dalton, 2005), and organizational citizenship behaviors (Coyle-Shapiro, 2002; Robinson, 1996; Robinson & Morrison, 1995), and increase intentions to quit (Suazo, 2009).

Psychological contract research has been conducted with professions from a wide variety of industries, e.g., government employees (Coyle-Shapiro, 2002), professional workers from the banking and hospital industries (Van Dyne & Ang, 1998), service employees (Suazo, 2009), and professional employees from aerospace, electronics, accounting firms (Porter, Pearce, Tripoli, & Lewis, 1998), all of which improve the generalizability of the research. Yet, there has been little empirical research sampling IT professionals, and until Martinez in 2004, no direct research of their psychological contract. And while some IT research supports differences between IT and non-IT professionals' attitudes and behaviors (Cougar, Zawacki, & Oppermann, 1979; Moore & Love, 2005), which justifies studying IT professionals, there is also research questioning those differences (Wynekoop & Walz, 1998). Current research offers no distinctions for the IT profession, and with the present volatility of the IT job market and high expectations of innovation and performance by management, this study empirically examines the relationship between the perceptions of the IT professionals' level of fulfillment of their psychological contract and their innovative work behavior and organizational citizenship behaviors.

In the sections that follow, we will present the theoretical framework and relevant literature to the study. We will discuss the research model and hypotheses. We then test our theoretical model using cross-sectional data and present the results. We conclude with a discussion of the implications of the findings for practice and research.

LITERATURE REVIEW

The study offers two complementary theoretical perspectives together in examining the IT professional's perceptions of the employer-employee relationship and resulting organizational behaviors. Researchers have drawn on Rousseau's (1989) psychological contract theory to help explain differences in employee attitudes and behaviors in the work place (Coyle-Shapiro, 2002; Janssen, 2000; Sels, Janssens, & Van Den Brande, 2004). The psychological contract perspective has also been applied to identify perceptions of IT outsourcing success (Koh, Ang, & Straub, 2004).

Salancik and Pfeffer's (1978) social information processing theory explains that employees receive social cues from not only their own behaviors, but also their employer's behaviors. These social cues can modify their beliefs of perceived obligations owed to and from their employers. Herriot and Pemberton (1997) parallel this view by proposing that development of the psychological contract is a social process, because beliefs of the contract originate from each party through direct or indirect communication.

This study uses both theories to examine the IT professionals' perceptions regarding their employers' fulfillment of those obligations within the realm of the psychological contract and the subsequent effects to their organizational behaviors – organizational citizenship and innovative work. Specifically, this study proposes to answer the question: What is the relationship between the level of fulfillment of the IT professionals' psychological contract and their organizational citizenship and innovative work behaviors?

Fulfillment of Psychological Contract

Rousseau (1989) defines the psychological contract as "an employee's beliefs regarding the terms and conditions of a reciprocal exchange agreement between that focal person and another party" (pg. 123). While the psychological contract is normally perceived as unwritten, it has "the power of self-fulfilling prophecies: they can create the future" (Rousseau, 1995, pg. 9). The employee's perceptions form the psychological contract, which in turn becomes a reciprocal obligation. Hence, the employee believes certain obligations, such as job security and good pay, are owed to the employer

after, for instance, an employee's loyalty or hard work (Rousseau, 1990). Consequently, the employee's psychological contract is the essence of the perceived relationship formed between the employee and employer, yet because the terms are subjective, the actual parties to this relationship may not necessarily agree to its terms (Rousseau, 1989).

The degree of fulfillment, change, breach or violation perceived within the context of the psychological contract refers to the instance where the employer may fail to live up to some aspect of their obligations, and the employee, in turn, believes less is owed to their employer (Robinson & Morrison, 1995; Robinson & Rousseau, 1994; Rousseau & Tijoriwala, 1998). Most research empirically measures the psychological contract or the fulfillment of the psychological contract using the evaluation or content approach, which examines the specific aspects or tangible terms of the perceived employer-employee relationship, e.g., employer's obligations of high pay and career development (Robinson, 1996; Rousseau, 1990; Van Dyne & Ang, 1998).

This study uses the dimensional approach, which characterizes distinctive properties and offers a more extensive understanding of the employee's psychological contract. It also offers an improved assessment in trying to understand the employee-employer relationship in today's dynamic employment environment. The diversity of employment arrangements within the IT industry warrants a more diverse understanding of today's IT professionals' employment situation (Agarwal, De, & Ferratt, 2001; Ang & Slaughter, 2001; Ferratt, Enns, & Prasad, 2001). Investigating the dimensions of the employment relationship might better fit the organizational and employment context of IT professionals (McLean Parks, Kidder, & Gallagher, 1998). This study adopted six dimensions of the psychological contract: stability, scope, tangibility, time frame, focus, and volition.

The stability dimension of the psychological contract refers to the extent the contract is constant or static opposed to dynamic and evolving as perceptions of obligations and entitlements framed within the psychological contract evolve in response to changing needs (McLean Parks et al., 1998). An IT professional whose organizational tenure or employment arrangement is short-term may have difficulty establishing trusting relationships, which enables a more flexible and malleable psychological contract, which is more common when job length is long-term.

Scope refers to the extent of the boundary between an IT professional's employment relationship and other portions of one's life, e.g., the amount an individual's work responsibilities spill over into their personal life (McLean Parks et al., 1998). The scope of the psychological contract can vary from very narrow to very broad.

Tangibility refers to the explicitness of the psychological contract with respect to the employee's degree of understanding to the defining boundaries, terms and expectations of the employment relationship, most important being that the specific terms of the contract are visible and are not ambiguous to third parties (McLean Parks et al., 1998). McLean Parks et al. (1998) proposes that the more specific and observable the terms of the employment contract and job description, the less likely the employee will go beyond the minimum requirements of the job.

Time frame dimension of the psychological contract has end points representing a close-ended, specific contract at one end and an open-ended, indefinite contract at the other end (Rousseau & Wade-Benzoni, 1994). McLean Parks et al. (1998) contends that an open-ended contract may be viewed as a long-term employment relationship; whereas, a close-ended contract may be characteristic of a short-term employment relationship. IT professional's time frame dimension may be affected if working in an organization with high turnover or outsourcing issues, versus if working in an organization with minimal turnover, as evidenced in EE Times (2005).

Focus of the psychological contract refers to the relative emphasis on economic versus socio-emotional concerns on one continuum with extreme end points for the two. For instance, a psychological contract geared toward material and monetary rewards at one end and truthfulness, sharing, respect, development opportunities, etc., at the other end is typical of a economic versus socio-emotional continuum (McLean Parks et al., 1998). Rousseau (1989) states that the longer employment relationships continue, there will be recurring exchanges of contributions, which in turn will strengthen the employee's perceptions of the relationship and fall more on the socio-emotional continuum.

Volition of the psychological contract is "the degree to which employees believe they had a choice in the selection of the nature of the employment relationship…" (McLean Parks et al., 1998, pg. 720). Volition also refers to alternatives one may or may not have with respect to jobs, because of their level of expertise, or specialized talents or skills (McLean Parks et al., 1998). Therefore, IT professionals may believe they have a higher level of volition when their skill set is unique or in demand.

When the organization fails to respond accordingly to their obligations as perceived by the employee, employees may construe the contradiction as some extent of non-fulfillment of their psychological contract. Even though this incongruence is a subjective experience, with any perceived non-fulfillment, employees may change their beliefs about what they subsequently owe their employer (Robinson et al., 1994; Rousseau, 1989). The effects of the non-fulfillment of the IT professional's psychological contract using the dimensional approach on their organizational citizenship behaviors and innovative work behavior has not been assessed in this context. Organizational citizenship and innovative work behaviors are described next.

Organizational Citizenship Behaviors

Smith, Organ, and Near (1983) defines OCB as the extra-role, discretionary actions that help others in the organization perform their jobs or show support for and conscientiousness toward the organization. Organ (1988) identifies five OCB dimensions: altruism, conscientiousness, civic virtue, courtesy, and sportsmanship, which have been used to investigate the relationship with trust and satisfaction (Rioux & Penner, 2001) and to identify an employee's motives toward OCB (Brief & Motowidlo, 1986). Many researchers have offered other perspectives to OCB (e.g., Borman, Penner, Allen, & Motowidlo, 2001; Brief & Motowidlo, 1986; Van Dyne & LePine, 1998), as well as recognized that it's logical to identify variables that might increase those behaviors in organizational settings (Podsaskoff, Whiting, Podsakoff, & Blume, 2009).

Van Dyne and Ang (1998) proposes that organizational citizenship can be regarded as a behavioral gauge of the employee's perceptions and subsequent responses to their relationship with their employer. The relevancy of these perceptions is important when IT professionals are placed in a work environment in which their job performance is partially judged by the amount of OCB performed. For example, Yen, Li, and Niehoff (2008) found that IT implementation teams exhibiting higher levels of OCB, resulted in more effective project management and information system success. It is instances such as these that citizenship behaviors continue to remain a vital component of the IT professional's performance and are essential for proper organizational practices (Moore & Love, 2005).

This study examines a set of organizational citizenship behaviors that have been used in prior research: helping, loyalty, advocacy participation, functional participation, and obedience (Ang & Slaughter, 2001; Coyle-Shapiro, 2002; Van Dyne & Ang, 1998), but not all within the context of IT professionals, yet these citizenship behaviors

fit within the conceptual realm of behaviors that might be expected of IT professionals.

Helping refers to discretionary actions that have some assisting effect and are directed at a specific individual or group and the task performed has some organizational relevance (Coyle-Shapiro, 2002; Smith et al., 1983; Van Dyne & Ang, 1998).

Graham (1991, pg. 255) and Van Dyne et al. (1994, pg. 767) define loyalty and obedience as follows: Loyalty refers to identifying with the organization and having allegiance to the organization, going beyond the "parochial interests of individuals, work groups, and departments." Typical behaviors include "defending the organization against threats, contributing to its good reputation, and cooperating with others to serve the interests of the whole." Obedience refers to accepting the "rules and regulations governing organization structure, job descriptions, and personnel policies." This would include such actions as having "respect for rules and instructions, punctuality in attendance and task completion, and stewardship of organizational resources."

Advocacy participation refers to "behaviors that are targeted at other members of the organization and reflect a willingness to be controversial" and "maintaining high standards, challenging others, and making suggestions for change (Van Dyne et al., 1994, pg. 780). This behavior might be an important component in project management team relationships.

Functional participation refers to behaviors that have a personal focus, yet still contribute to organizational effectiveness, such as "performing additional work activities, self-development and volunteering for special assignments" (Van Dyne et al., 1994, pg. 780).

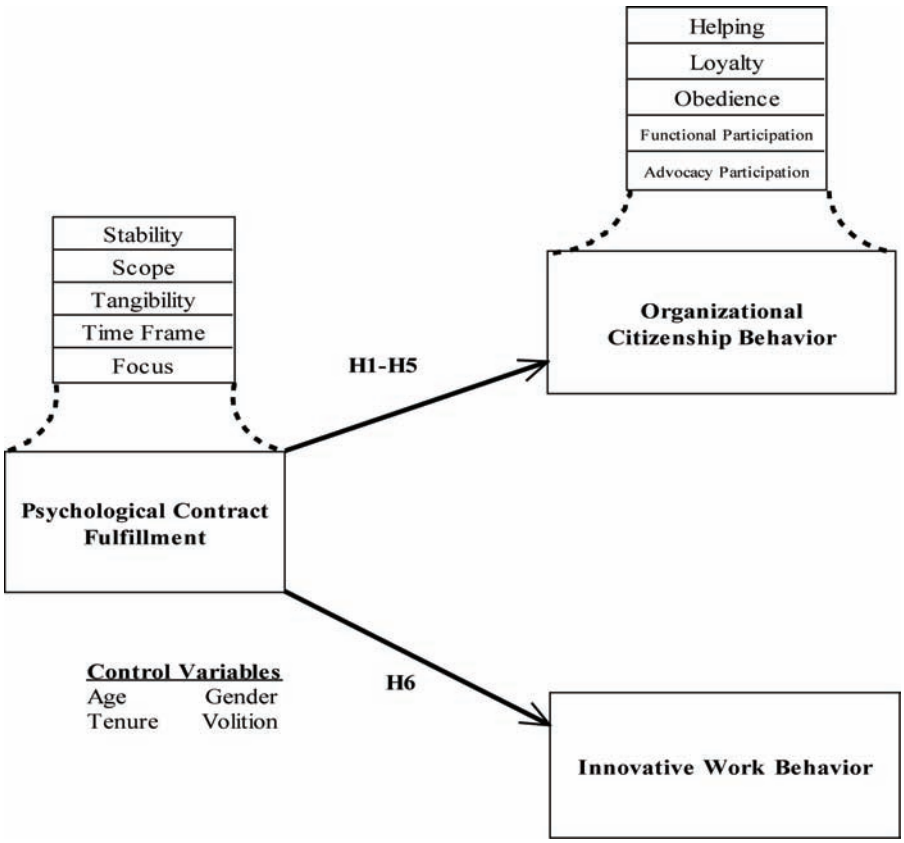
Innovative Work Behaviors

The concept of innovation is defined a multitude of ways (Kanter, 1983; West & Farr, 1990b; Zaltman, Duncan, & Holbek, 1973). Using West and Farr's (2000) definition, Janssen (2000) finds the level to which workers respond innovatively to their job is determined by their perceptions of fairness on the job. In a different study, the employee's perceived obligation to innovate, job autonomy, and pay have a direct effect on their innovative work behavior (Ramamoorthy, Flood, Slattery, & Sardessai, 2005). In the same realm as innovative work, empirical evidence indicates that perceptions of an employee's work environment and creativity climate directly affects the creativity of projects (Amabile, Conti, Coon, Lazenby, & Herron, 1996). Clinton, Hardgrave, and Armstrong (2005) finds the interaction of IT professionals and their environment most important when examining the person-job cognitive style fit on innovative performance. Supporting anecdotal evidence found in the popular press (Koch, 2006; Murphy, 2005), this study examines innovative work behavior, which are planned actions that hope to accomplish some beneficial result, as defined by Janssen (2000).

RESEARCH MODEL AND HYPOTHESES

The psychological contract and social information processing theories are adapted to predict two organizational behaviors of IT professionals, organizational citizenship and innovative work. Using the dimensional approach to the psychological contract, the IT professional's perceptions of their employer's fulfillment of their obligations are investigated as predictors of their organizational behaviors. The research model for this study is shown in Figure 1. From left to right, the level of fulfillment of the psychological contract using five dimensions (stability, scope, tangibility, time frame, and focus) are proposed to affect each of the IT professional's five organizational citizenship behaviors (helping, loyalty, obedience, functional participation, and advocacy participation) and innovative work behavior. The model depicts

Figure 1. Research Model with Hypotheses



four control variables: volition (a dimension of the psychological contract), and age, gender, and tenure, which are discussed later in the paper.

The key assertion in the study is that higher levels of fulfillment of the IT professional's psychological contract will positively affect the relationship with their organizational citizenship behaviors and innovative work behavior. Studies using the content or evaluative approach have found psychological contract violations related to lower extra-role behaviors (Robinson & Morrison, 1995), lower performance and civic virtue behavior, (Robinson, 1996), lower OCB (Coyle-Shapiro, 2002), as well as lower trust and job satisfaction. Robinson and Morrison (1995) found employees less likely to perform civic-minded behaviors when they felt their employer had not fulfilled their obligations to the perceived contract.

Even though citizenship behaviors are viewed as a collective act by Organ (1988), researchers often consider OCB as a multi-dimensional construct and look at the significance of each dimension under study (Coyle-Shapiro, 2002), or investigate selective dimensions of OCB (Ang & Slaughter, 2001; Robinson & Morrison, 1995; Van Dyne & Ang, 1998). As such, it is proposed that higher perceptions of their employer's fulfillment of their obligations (within the IT professional's psychological contract) will be positively related to higher levels of each of the dimensions of OCB under study: helping, loyalty, obedience, functional participation, and advocacy participation. The five hypotheses below reflect this distinction:

Hypothesis 1: Higher perceptions of fulfillment of their employers' obligations of the

psychological contract will be positively related to higher levels of the IT professionals' organizational citizenship behavior dimension - helping.

Hypothesis 2: Higher perceptions of fulfillment of their employers' obligations of the psychological contract will be positively related to higher levels of the IT professionals' organizational citizenship behavior dimension - loyalty.

Hypothesis 3: Higher perceptions of fulfillment of their employers' obligations of the psychological contract will be positively related to higher levels of the IT professionals' organizational citizenship behavior dimension - obedience.

Hypothesis 4: Higher perceptions of fulfillment of their employers' obligations of the psychological contract will be positively related to higher levels of the IT professionals' organizational citizenship behavior dimension – functional participation.

Hypothesis 5: Higher perceptions of fulfillment of their employers' obligations of the psychological contract will be positively related to higher levels of the IT professionals' organizational citizenship behavior dimension – advocacy participation.

Innovative work behaviors, as well as citizenship behaviors, have been thought of as extra-role behaviors that are not obligatory, are outside the normal job description requirements, and are not clearly distinguished within the formal reward system (Katz & Kahn, 1978; Organ, 1988). In Janssen's (2004) investigation of fairness perceptions in non-management employees' relationship between job demands and innovative work behavior, he finds the level to which the employees respond innovatively to their job is determined by their perceptions of fairness on the job. Thus, it is proposed that one's perceptions of the level of fulfillment of their employer's obligations will be positively related to one's innovative work behavior. Accordingly, the following research hypothesis is proposed:

Hypothesis 6: Higher perceptions of fulfillment of their employers' obligations of the psychological contract will be positively related to higher levels of the IT professionals' innovative work behavior.

METHODOLOGY

Procedure and Sample

Data were collected from a convenience sample of working IT professionals located throughout the United States. The questionnaire was administered through two means: an on-line survey and a group-administered paper survey. Participation was strictly voluntary. The respondents were obtained from two sources: alumni from the management information systems program and graduate students in management information systems program evening classes of a major southeastern university.

For the on-line survey, a letter of invitation to participate was mailed to the intended respondents. A postcard was mailed about three weeks after the first mailing as a follow-up reminder to those who had not yet responded.

Three hundred twenty-four responded to the survey. Of that number, 251 completed the on-line survey, 36 completed the group administered survey, and 37 responded to the on-line survey, but did not complete the questionnaire. The overall response rate was 9.7% with 287 responding out of 2,950 potential respondents. Possible factors influencing the response rate was the length of the questionnaire and the controls established within the on-line survey, in that those responding to the on-line survey had to answer a minimum number of questions to successfully submit the questionnaire. Basic demographic information was asked for in the event the respondent could not or chose

not to complete the survey. This enabled verification that those who did not participate were not so different from those who chose to participate. T-tests conducted found no significant differences between those who responded to the survey and those who chose not to respond; therefore, potential non-response bias was negligible.

Only those respondents who were permanent employed IT professionals were used in this study, providing 209 usable questionnaires. With two sources of data, group administered (n = 18) and on-line survey (n = 191), and the initial and second mailings inviting those to participate in the on-line survey, method bias was also assessed. Again, t-tests were conducted, and no significant differences in any of the demographics collected at $\alpha = .01$.

Measures

To stay consistent with prior research, all scales in the measurement instrument, except focus and volition, were adopted from existing instruments with proven reliabilities. In an effort to have consistent end choice points throughout the measurement instrument, any scales not having choice end points of 1-6 were changed to choice end points of 1-6, which forces a non-neutral choice on behalf of the respondents (Spector, 1992).

The items measuring psychological contract fulfillment, OCBs, and innovative work behavior are presented in Tables 2, 3, and 4. Psychological contract fulfillment dimension scales for stability, scope, tangibility, and timeframe were adapted from Sels and his colleagues (2004). Specifically, respondents were asked to indicate "the extent to which you believe the organization has fulfilled this obligation to…"

Measurement items for the focus and volition dimension were developed for this study. Using the domain definition from McLean Parks et al. (1998), five items were developed to measure and operationalize the focus dimension as it relates to the fulfillment of the psychological contract. Volition was measured as a single item. Respondents were asked, "Which employment arrangement would you prefer to work?" This response was compared to their current employment arrangement, which they provided, and this provided an indication as to whether their current arrangement was voluntary (Morrow, McElroy, & Elliott, 1994; Stamper & Van Dyne, 2001). Following McLean Parks et al.'s (1998) conceptualization of volition, volition is also hypothesized to be a control variable in the research model.

The OCB dimensions helping, loyalty, advocacy participation, functional participation, and obedience were measured using items adapted from Coyle-Shapiro (2002). Innovative work behavior was measured using the eight-item scale developed by Janssen (2000), which assesses Kanter's (1994) three stages to innovation: idea generation, idea promotion, and idea realization.

Researchers find that certain demographic characteristics tend to correlate with outcome behaviors. Forms of OCB may be a function of tenure and thus, tenure may be a moderator between antecedents and OCB (Organ and Ryan 1995). Organ and Ryan (1995) also argue that gender might be a predictor of OCB, considering the beliefs that females may perform more aspects of OCB, e.g., altruism and courtesy factors. In their study investigating OCB in restaurant employees, Stamper and Van Dyne (2001) find age, gender, and organizational tenure related to their work status. Accordingly, age, gender, tenure in the employment arrangement, and volition assessed and statistically controlled in this study,

DATA ANALYSIS

All data analysis was accomplished using SPSS. Pearson correlations were used in the analysis of correlations between the constructs. Analyses of the factor structures were examined using informal confirmatory factor analysis with Promax rotation and extracting the number of factor theorized in

Table 1. Demographic profile of respondents

(n = 209)	Mean	Median	Range
Age	38 years	37 years	22 – 64 years
Employment tenure	5 ½ years	5 years	Less than a year – 25 years
Gender	Female: 73 (35%), Male: 136 (65%)		
IT Field	Database Development 16%, Programming & Software Engineering 34%, Technical Support 18%, Enterprise Systems & Analysis 16%, Network Design & Administration 10%, Other 6%		

the literature. Promax rotation method was used due to moderate correlations among the factor items, which are shown in the Appendix.

Sample Characteristics

The IT professionals responding to this study reflect a representative sampling comparable to the IT workforce as described by ITAA's (2005). The respondents held a wide variety of IT job titles and were in all of the Information Technology Association of America's (ITAA) career field clusters except one (technical writing). The study sample was well educated with 85% having at minimum a bachelor's degree. Approximately 45% had attended formal education within the past five years. The demographic data (see Table 1) supports ITAA's 2005 report that "The IT labor force is a highly skilled, highly educated population" (pg. 6). The study sample and ITAA IT workforce were also comparable in median age, percentage over 45 years of age, and gender. Median age for the sample was 37 years, 25% were over 45 years of age, and 35% were female. Eighty-eight percent of the IT professionals were in their preferred employment arrangement, while 10.2 percent preferred another arrangement. Median tenure in their employment arrangement was five years.

Reliability and Validity of Constructs

Content validity of the measurement instrument was established mainly through the adoption of existing instruments and use of recommended concepts found in the literature. With the development of new measurement items for the focus dimension of the psychological contract, particular attention was taken during pre-testing with domain experts and pilot-testing of the instrument. All reliabilities were above Nunnally and Bernstein's (1994) recommended acceptable level of at least .70 with one exception. The reliability for OCB obedience was $\alpha = .61$, which closely follows the $\alpha = .63$ reliability in Coyle-Shapiro's (2002) study. Means, standard deviations, and inter-correlations of the study variables are shown in the Appendix, as well as the study variables' internal reliabilities (Cronbach's alpha) at the diagonal.

Construct and discriminant validity were assessed through informal confirmatory factor analysis and found to be satisfactory. Five factors extracted for fulfillment of the psychological contract explained 75.5% of the variance; five factors extracted for OCB explained 72.9% of the variance; and the one factor for IWB explained 62% of the variance. An evaluation of convergent validity was possible for two study variables, OCB advocacy participation and innovative work behavior. The measurement items in each variable relate to sharing ideas, making improvements, suggestions, etc., and the two study variables were found to be correlated at $\alpha = .703$. Tables 2, 3, and 4 present the measurement items used in the questionnaire for each factor and the factor loadings from the pattern matrix for fulfillment of the psychological contract, OCB and IWB.

Table 2. Measurement items with factor loadings for fulfillment of the psychological contract

Measurement Items	Factor Loadings
Time Frame	
Provide me with job security	**.876**
Make a commitment to me for a long time	**.906**
Won't immediately release me if things are going badly	**.834**
Offer me another job if my current job would disappear	**.770**
Do everything in their power to keep me on the job	**.713**
Scope	
Appreciate me for what I do and who I am	**.882**
Consider not only the end result, but also my personal effort	**.855**
Treat me as a person, not as a number	**.824**
Allow me to be myself within this firm	**.865**
Focus	
Notify me of any available financial rewards	**.680**
Establish a respectful and trusting relationship	**.664**
Provide development opportunities	**.839**
Provide any and all materials necessary to do the job	**.970**
Be truthful even when it may harm the relationship	**.487**
Tangibility	
Specifically describe the performance appraisal criteria used in this firm	**.770**
Unambiguously describe my obligations within this firm	**.925**
Unambiguously describe my rights within this firm	**.674**
Stability	
Stick to agreements despite changing circumstances	**.783**
Consider written or oral agreements as permanently valid	**.996**

Results

The items retained for each construct were summed and averaged creating the variables used in the analysis. Separate regression analyses were performed with each of the organizational citizenship and innovative work behaviors as the dependent variables and the five dimensions of fulfillment of the psychological contract, as the independent variables. To control for other factors potentially confounding the relationship between the level of fulfillment of the psychological contract and the organizational behaviors, age, gender, tenure in the employment arrangement, and volition were included in the regression equations. All variables were entered into the regression simultaneously.

As Table 5 shows, perceived higher levels of fulfillment of the psychological contract dimensions were positively related to four dimensions of citizenship behavior – loyalty and advocacy participation ($p < .001$), obedience ($p < .01$), and functional participation ($p < .05$), providing support for Hypotheses 2-5. Hypothesis 1 was not supported by the data; no relationship was found between perceived levels of fulfillment of the

Table 3. Measurement items with factor loadings for OCB

Measurement ItemsAdvocacy Participation	Factor Loadings
I make creative work-related suggestions to co-workers	**.872**
I make innovative suggestions to improve the functioning of the department	**.844**
I share ideas for new projects or improvements widely	**.776**
I encourage others to speak up at organizational meetings	**.843**
Loyalty	
I tell outsiders that this organization is a good place to work.	**.942**
I defend the organization when other employees criticize it	**.822**
I represent the organization favorably to outsiders	**.899**
Functional Participation	
I work beyond what is expected	**.852**
I exceed formal requirements of the job	**.914**
I go the 'extra mile' for the organization	**.837**
Helping	
I help others who have heavy workloads	**.905**
I help others who have been absent	**.918**
I go out of my way to help colleagues with job-related problems	**.707**
Obedience	
I neglect aspects of job responsibilities	**.846**
Regardless of circumstance, I produce the highest quality of work	**.535**
I follow work rules and instructions with extreme care	**.742**

psychological contract dimensions and OCB helping. Perceived higher levels of fulfillment of the psychological contract dimensions were also positively related to innovative work behavior at $p < .001$, providing support for Hypothesis 6.

Table 6 highlights significant predictor variable regression coefficients of all regression equations, except for OCB helping, which was not significant.

Table 4. Measurement items with factor loadings for IWB

Measurement Items	Factor Loadings
I create new ideas for difficult issues	**.767**
I search out new technologies, processes, working methods, techniques, and/or product ideas	**.703**
I generate original solutions for problems	**.734**
I mobilize support for innovative ideas	**.801**
I make organizational members enthusiastic for innovative ideas	**.759**
I transform innovative ideas into useful applications	**.771**
I introduce ideas into the work environment in a systematic way	**.698**

Table 5. Regression analysis results explaining variance in organizational behaviors

Dependent Variable	*R*	R^2	R^2_{Adj}	*F*
OCB Loyalty	.76	.57	.55	28.01***
OCB Advocacy Participation	.44	.19	.16	5.09***
Innovative Work Behavior	.43	.18	.15	4.74***
OCB Obedience	.34	.12	.07	2.73**
OCB Functional Participation	.30	.09	.05	2.12*

*p <.05, ** p <.01, ***p <.001

DISCUSSION

Innovative work and citizenship are two qualities deemed vital to an IT professional's conduct. In today's world, businesses are constantly changing to adapt to competitive pressures, and they depend on their IT talent to help facilitate that process through their creativity and innovation. Whether the job is to beat the competition or just keep up, innovation remains the goal (Kanter, 2006; Varon, 2005). Citizenship behaviors, such as loyalty, advocacy participation, obedience, functional participation, and innovative work behavior on the part of IT professionals are still important to overall organizational success, even when the job is less clear (Moore & Love, 2005).

Organizational Citizenship Behavior

The individuals' organizational citizenship behaviors can be a gauge of their responses to their relationship with their employer (Van Dyne & Ang, 1998). IT professionals, who perceive the relationship with their employer is not what it should be, may retreat from their level of involvement within the job or project or withdraw from active participation, or even start to become complacent in their work. Yet, Yen et al. (2008) found that cooperative and helping behavior has a significant impact on information system success.

Applying psychological contract and social information processing theories, the results of this study provide empirical evidence to indicate that increased levels of fulfillment of the IT profession-

Table 6. Regression equation using significant predictor variables to explain variance in scores for organizational behaviors

	Loyalty	**Advocacy Part**	**Innovative Work Behavior**	**Obedience**	**Functional Part**
Predictor Variable[a]	*β*	*β*	*β*	*β*	*β*
PC Scope	.49***	.22*	.23*		
PC Focus	.31***				
Age	.13*				
PC Tangibility		.35***	.25*	.22*	
PC Volition			.17*		
Gender				-.28***	-.15*

*p <.05, **p <.01, ***p <.001, [a]Predictor variables – PC Stability, PC Time Frame and Tenure were not significant in any regression equation, hence omitted from table list.

als' psychological contract are positively related the IT professionals' increased performance of organizational behaviors.

This study has examined in greater depth than prior research the importance the IT professional's perception that the psychological contract between the employee and employer has been fulfilled and the potential impact this has on organizational citizenship behaviors. Even though these behaviors are subtly expected by supervisors, they fall outside the traditional productivity and task performance measures (Ang & Slaughter, 2001). Employees, if they perceive that promises have not been met have the potential to "under perform" in areas that are not directly observable by the manager. The IT professionals' citizenship behavior, especially advocacy participation, is strongly affected by the scope and tangibility dimensions of the psychological contract.

Scope refers to the level that the employer typically fulfills their obligations, such as expressing appreciation of the IT professional's work, taking the IT professional's personal effort into consideration, and their treatment of them. Therefore, the IT professional might speak out more while making creative and innovative suggestions, share ideas, and encourage others to speak up, and thus supporting the organization overall, the more the IT professional felt their employer had fulfilled their obligations to express their appreciation to them. Or the direct opposite is true; the IT professional may fail to speak up, share ideas, or make innovative suggestions, if they feel that their employer has not fulfilled their obligations related to scope.

High levels of fulfillment of the tangibility dimension of the psychological contract, the explicitness to defining the boundaries, terms and expectations of the employment relationship, was also positively related to high levels of advocacy participation. Acquisition for technology companies can be challenging for IT professionals, in that innovation and creativity are still expected, even during changes to the organizational structure (Christensen, 2006). Therefore, the clearer the terms of the employment contract and the employer respecting and upholding those terms, the more willing the IT professional will be to make suggestions and share ideas.

High levels of fulfillment of the scope and focus dimensions of the IT professional's psychological contract were positively related to the IT professional's OCB dimension – loyalty. Therefore, the IT professional's level of loyalty to the organization, can be influenced by the amount the employer expresses appreciation of the IT professional's work, takes the IT professional's personal effort into consideration, and treats them with respect, which relate to the scope dimension. For this study, the IT professionals' focus represents a more socio-emotional concern in their psychological contract. Consequently, the more the IT professional feels that the employer has fulfilled their obligations to provide development opportunities, provide a trusting and respectful employment relationship, and be truthful, the more the IT professional is willing to be loyal and defend the organization. Age is also found to be a significant predictor of loyalty, in that older IT professionals indicate greater loyalty to the organization than younger IT professionals.

High levels of fulfillment of the tangibility dimension of the psychological contract were positively related to high levels of the OCB dimension – obedience. The tangibility dimension again refers to the explicitness to defining the boundaries, terms and expectations of the employment relationship. Therefore, the clearer the terms of the employment contract and the more the employer respected and upheld those terms, the more inclined the IT professional was to produce quality work, follow rules and not neglect aspects of their job responsibilities.

The study corroborates prior research by Organ and Ryan (1995), in that females exhibited higher levels of organizational citizenship than males. Females indicated higher obedience than males. Gender was the sole significant variable

in explaining the OCB dimension – functional participation, which relates to higher levels of working beyond expectations, or exceeding formal job requirements, and going the extra mile.

Innovative Work Behavior

The relationship between employee and employer is tenuous in today's IT labor market. The scope and tangibility dimensions of the psychological contract had the most influential effects in the relationship. Managers making simple gestures, such as expressing appreciation to their IT professionals can improve a situation considerably (Motti, 2006). This study finds that if employers fulfilled their obligations to express appreciation of the IT professional's work, consider their personal effort in the performance of their jobs, improve their treatment of them, and stick to agreements, the IT professional was motivated to perform greater levels of innovative work behavior, such as create new ideas, search out new processes, transform innovative ideas into useful applications, etc. West and Farr (1990a) recognize innovative work behavior can be an intentional act, which can be withheld, as easily as it can be performed. The innovativeness and creativity of IT professionals remains a vital component to the organization, and the ability of the employer to improve perceptions of the employer-employee relationship is found to be a common denominator in the equation.

The IT professional's volition, or their preferences for their permanent employment arrangement, was also found to affect their innovative work behavior. However, it was the IT professional, who preferred an employment arrangement other than their permanent arrangement, who indicated higher levels of innovative work. This suggests that perhaps the IT professionals engage in innovative work as a means to facilitate some other objective.

CONCLUSION

An important contribution of this study is its investigation into the innovative work behavior of IT professionals. While research continues to investigate the motives and cognitions around creative and innovative work behavior (Christensen, 2006; Janssen, 2000; Ramamoorthy et al., 2005), this study finds that some aspect of the IT professional's innovative work behavior may be determined by the level of fulfillment of their psychological contract. Recognizing the importance of how IT professionals perceive their environment, these perceptions can affect their creativity, which is the seed of all innovation (Amabile et al., 1996).

Another important contribution of this study is in the use of the dimensional approach to the psychological contract. This more expressive view of the perceptual nature of the psychological contract explored the underlying dimensions of the psychological contract, while assessing the level of fulfillment. The dimensional approach enabled examination of the psychological contract and its affect on employee behavior by seeking to understand in greater depth, the motivations behind the IT professional. This is an improved illustration over the content approach of the psychological contract, especially with the increasingly complex employer-employee relationship of those in the IT industry.

A strength of this study is in the research methodology as it relates to the data collection and the sample. The administration of the questionnaire was through two means: an on-line survey and a group-administered paper survey, and the respondents were obtained from two sources: alumni from the management information systems program and graduate students in management information systems program evening classes of a major southeastern university.

This study used cross-sectional data and was strictly based on self-report data and did not look at IT employee evaluations by peers or supervisors.

As in all research that involves self-report data, there is the potential for self-report bias (Organ & Ryan, 1995; Spenner, 1990); however, Spector (1987) contends that the typical criticism in using self-report measures involving attitude and perception measures may not be factual. Rioux and Penner (2001) obtained ratings from a number of different sources, e.g., self, peers, and supervisors, in an effort to minimize mono-method bias and found self-ratings of OCB comparable to both peer and supervisor ratings.

Possible factors influencing the low response rate of 9.7% was the length of the questionnaire and the controls established within the on-line survey. Those responding to the on-line survey also had to answer a minimum number of questions to successfully submit the questionnaire.

The psychological contract dimensions first empirically tested by Sels et al. (2004) and then analyzed in this research require additional studies to further validate and improve the scales, particularly stability. The focus scale, which was developed for this study, also requires further validation and improvement. The low adjusted R^2 values of the regression models suggest that there are other factors, such as job demands, perceptions of fairness, or personality factors, that may help to further explain the organizational behaviors of IT professionals (Organ & Ryan, 1995), and should be investigated.

For practitioners, the results indicate that the IT professional's perceptions are very relevant in the employee-employer relationship, as Karl Weick so aptly stated, "believing is seeing" (2001, pg. 195). The strong relationship found between the OCB dimension – loyalty and the IT professional's level of fulfillment of their psychological contract sends an unmistakable message to management for the continued need for clear communication between employer and employee. Shore and Tetrick (1994) contends that if organizations don't understand the employee's psychological contract under which they are operating, some strategic business decisions for cost savings and improvements may result in violations to the employee's psychological contract. And as seen in this study, the IT professional's performance of organizational behaviors, specifically their citizenship behaviors - loyalty, obedience, advocacy participation and most importantly innovative work behavior, are affected by their perceptions of their employer's fulfillment of psychological contract obligations to them.

Management has the ability to improve the employer-employee relationship by focusing on and addressing specific issues found within the dimensions relating to the IT professionals' psychological contract. Management could conceivably ask employees to anonymously rate the company's performance on issues such as being clear about opportunities for advancement, improving trust within the organization, providing development opportunities, and finding ways to show appreciation for work performance Low scores may suggest that the employer look closely at its practices in certain key areas. Yen, et al. (2008) found that training in cooperation and helping behaviors within project management teams influenced their success and when team members went above and beyond their job descriptions, projects were more successful. Using the dimensions of the psychological contract offers tangible employment relationship topics for management to identify and improve upon; it might be something as simple as investing in training opportunities or looking for tangible ways to show appreciation for a job well done (Motti, 2006).

Future research should extend this study by including IT professionals in relevant employment arrangements other than permanent full-time. Sourcing IT jobs beyond the permanent full-time employee has most likely altered how many human resource and management issues are executed (Ang & Slaughter, 1995), and the variability of employment arrangements for IT professionals or their working conditions is not likely to stabilize with continued offshore outsourcing, downsizing, or healthcare cost shifting (Koprowski, 2005).

The dimensional approach to the psychological contract tells a more comprehensive story of the IT professional's understanding of their employer's obligations to them and as to what influences their subsequent behaviors, both organizational citizenship and innovative work. This study demonstrates that this approach might also be appropriate when investigating IT professionals in varied employment arrangements. Saying this however, future research might address how important the psychological contract.

The construct, OCB, has received attention referring to the need of better identifying its dimensions (Van Dyne et al., 1994), because of the blurring of the separation between in-role performance and OCB. Most OCB studies have been subject to non-managerial or non-professional respondents. IT professionals do not likely fall into these categories, and hence with their job descriptions, in-role performance and OCB may be harder to distinguish. Organizational behaviors, OCB and IWB, were the focus in the study. Future research might consider investigating whether organizational behaviors within the OCB and IWB domain are considered in-role or extra-role behaviors by IT professionals. Other research might address what supports or leads to cultural or innovative behaviors within organizations.

With the ever-changing roles of the IT professional, management is challenged to understand how the employee perceives their role and the organization's role in achieving cutting-edge performance and creating competitive advantage in this global workforce. This study does not provide all the answers to understanding what affects their behaviors. However, we believe we have expanded our understanding of how IT professionals perceive their employment relationship and how the extent that the employer has fulfilled their obligations to the IT professional that this affects their subsequent innovative work and organizational citizenship behaviors.

ACKNOWLEDGMENT

The authors would like to acknowledge Richard P. Will, co-author of the original article on which this revision is based. The authors would like to thank the editor-in-chief of the *Information Resources Management Journal*, Mehdi Khosrow-Pour, and the anonymous reviewers or their helpful comments on previous versions of the original article.

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APPENDIX

Table 7. Means, standard deviations, correlation, internal reliabilities among the study variables†

	Mean	SD	Age	Gender	Tenure	Volition	Time Frame	Tangi-bility	Scope	Sta-bility	Focus	OCB Loyal	OCB Obed	OCB AP	OCB Help	OCB FP	IWB
Age	37.62	9.12															
Gender			-.065														
Tenure	5.51	4.28	.408**	-.094													
PC Volition			.014	-.010	-.159*												
PC Time Frame	4.15	1.24	-.212**	-.015	.048	-.169*	**.89**										
PC Tangibility	3.90	1.35	-.110	.068	.082	-.128	.589**	**.86**									
PC Scope	4.29	1.18	-.134	-.006	.058	-.126	.652**	.587**	**.92**								
PC Stability	3.84	1.26	-.230**	-.036	-.146*	-.121	.562**	.558**	.671**	**.80**							
PC Focus	4.08	1.15	-.192**	.065	.017	-.146*	.649**	.692**	.755**	.665**	**.88**						
OCB Loyal	4.39	1.27	-.014	.022	.090	-.137	.546**	.491**	.715**	.501**	.670**	**.87**					
OCB Obed	4.39	.96	-.053	-.242**	-.107	-.015	-.035	.105	.016	.080	.052	.029	**.61**				
OCB AP	4.39	.45	.043	.084	.089	.057	.167*	.344**	.283**	.238**	.223**	.252**	.219**	**.84**			
OCB Help	4.40	.22	-.071	-.108	.025	-.064	.029	.061	.076	.140*	.038	.064	.247**	.301**	**.83**		
OCB FP	4.94	.24	.019	-.126	.030	.043	.162*	.203**	.221**	.131	.202**	.328**	.385**	.488**	.355**	**.84**	
IWB	4.29	.35	-.083	.108	-.001	.113	.166*	.314**	.284**	.289**	.253**	.230**	.198**	.670**	.254**	.443**	**.92**

**p<0.01 (2-tailed) *p<0.05 (2 tailed) †Cronbach's Alpha for the corresponding variable is at the diagonal in bold.

Chapter 20
Inter-Team Negotiation Support, Coalition Formation, and Negotiation Outcomes: An Empirical Study

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ABSTRACT

This chapter is an attempt to investigate the role of negotiation support systems (NSS) in supporting inter-team negotiations, which have become commonplace for today's business negotiations. Inter-team negotiations differ from simple dyadic negotiations, and are associated with enormous complexity introduced by the negotiating team dynamics. When there are three or more members in a negotiating team, coalition formation by team members stands out as an intriguing phenomenon, of which cultural diversity is a primary antecedent. NSS through altering coalition formation dynamics have important impacts on various negotiation outcomes. An experiment was conducted to test the authors' research model and hypotheses. A content analysis was undertaken to measure the extent of coalition formation. Besides the quantitative approach, a qualitative analysis was also conducted to further enhance our exploratory efforts in examining the phenomenon. The results provide initial evidence of the usefulness of NSS in supporting inter-team negotiations, and have both theoretical and practical implications.

INTRODUCTION

Negotiation has been treated as persuasive social processes, involving dyads, small groups, organizations or governments in an attempt to "define or redefine the terms of their interdependence" (Walton & McKersie, 1965 p. 3). Much research on cognitive and social processes of negotiation has been conducted in the context of dyadic interpersonal

DOI: 10.4018/978-1-60566-962-5.ch020

negotiations. However, today's organizations are increasingly relying on teams as the prevalent mode for negotiations. In line with Lewicki et al. (2003), we adopt the term *inter-team negotiation* to describe the situations where two or more co-negotiators sharing interests and priorities negotiate with two or more co-negotiators on the other side who share their own interests and priorities. A few negotiation researchers have looked into inter-team negotiations (see Lewicki et al., 2003 for a review). Nonetheless, there is an absence of the examination into the *intra*-team dynamics, which constitute an important level of analysis in the study of inter-team negotiations. When there are three or more members in a negotiating team, the phenomenon of coalition formation could easily arise. In terms of group structure, coalition formation can be seen as a step upward from individual controls to integrated preferences, which if consistently occurs between a subset of members, is conceivably detrimental to the inter-team negotiation process and outcomes.

Negotiations are seen as complex, ill-structured and evolving tasks that require sophisticated decision support. Negotiation support systems (NSS) have thus been materialized as a special class of group support systems catered towards bargaining, consensus seeking and conflict resolution (Bui et al., 1992). As NSS have been mostly studied in dyadic interpersonal settings, it is necessary to examine their potential in supporting inter-*team* negotiations. An array of research issues would need to be addressed. Among these, coalition formation is a phenomenon unique to the team setting. This paper focuses on how NSS alter the extent of coalition formation in a negotiating team and in turn impact upon various negotiation outcomes.

Globalization has increased cultural diversity in organizations. Diverse culture introduces diverse perspectives which are conducive to organizational innovation. Notwithstanding the above, cultural diversity also introduces anxieties and conflicts. Cultural differences in negotiation have received considerable attention from researchers. However, cultural diversity and its consequences for inter-team negotiation have not yet been explored. We posit that cultural diversity in a negotiating team has a profound impact on the extent of coalition formation. Such postulation will be examined theoretically and empirically in this paper.

The rest of the paper is organized as follows. The important literature that has informed the study will first be reviewed in the following section on conceptual background. Based on the extant literature, the research model is proposed and the hypotheses are derived. We then proceed to elucidate the research method of the study, which involves essentially a laboratory experiment in verifying the research model and hypotheses. Analysis is subsequently performed on the empirical data collected; implications of the empirical findings are discussed. The paper is then concluded, with limitations pinpointed and future research opportunities highlighted.

CONCEPTUAL BACKGROUND

Coalition Formation

A coalition is defined as two or more parties who cooperate to obtain a mutually desired outcome that satisfies the interests of the coalition rather than those of the entire group within which it is embedded (Murnighan, 1986). Lau and Murnighan (1998) posit that faultlines and coalition formation are closely connected. According to them, group faultlines can be conceived as hypothetical dividing lines that may split a group into subgroups based on one or more attributes; depending on the similarity and saliency of group members' attributes, groups may have many potential faultlines, each of which may activate or increase the potential for particular subgroupings. Lau and Murnighan (1998) also suggest that task characteristics moderate how faultlines exaggerate or mitigate subgroup formations; especially

at early stages of group development, task type may exacerbate perceived differences among subgroups.

The theorization of faultlines can be based on the self-categorization theory (Turner, 1987), social identity theory (Tajfel, 1978), and the similarity-attraction paradigm (Byrne, 1971). Correspondingly, coalitions can only exist when individuals identify with certain groupings and categorize themselves as belonging to the particular groups (Thatcher et al., 2003). When coalitions are born, the embedding workgroup is divided, with its communication and task interdependence damaged; the processes that group members typically go through to negotiate common agreements are hindered (Clark et al., 2000). The formation of coalitions may also decrease the morale of group members and cause their dissatisfaction with the group process (Thatcher et al., 2003).

Negotiation Support Systems

Negotiation support systems (NSS) are defined as a special class of group support systems catered towards bargaining, consensus seeking and conflict resolution (Bui et al., 1992). Lim and Benbasat (1993) envision two major components for NSS: decision support systems (DSS) for each negotiator and an electronic linkage between the DSS so that the negotiators may communicate electronically. They also emphasize that it is important to evaluate the impact of each of the two instead of evaluating NSS as a single entity.

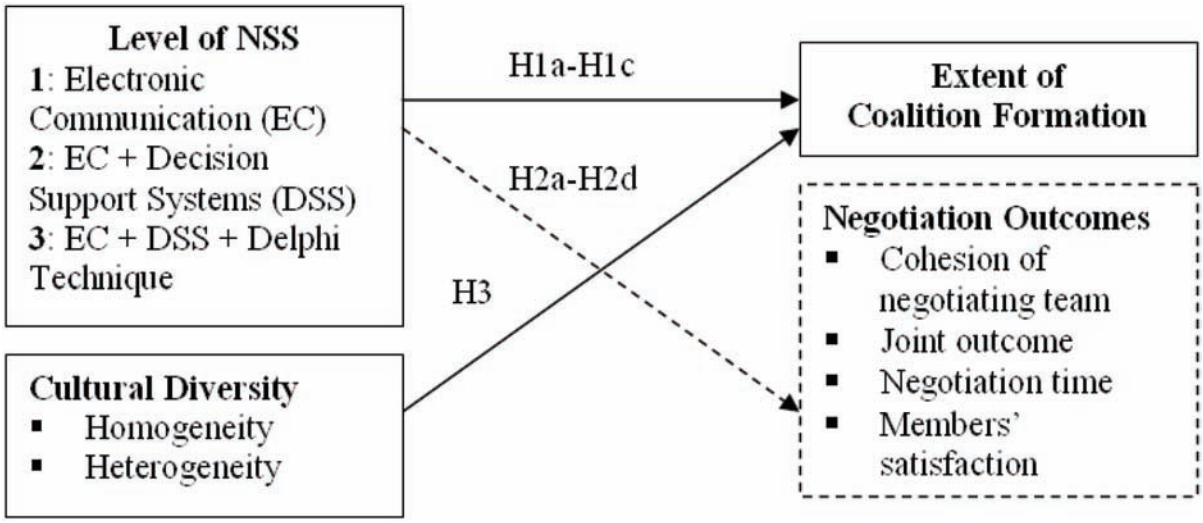
Previous studies have shown that the availability of NSS components impacts upon various aspects of negotiation outcomes, including individual outcome, joint outcome, contract balance, negotiation time, perceived climate, and satisfaction (see Starke & Rangaswamy, 1999 for a comprehensive review of the eight empirical studies of NSS that could be located in the literature by then). As NSS are re-actualized in the e-business context (e.g., Goh et al., 2000), extensive interest has been shown in "automated negotiation", where computational agents find and prepare contracts on behalf of the real-world parties they represent (Beam & Segev, 1997). Researchers believe that thus far the use of automated negotiation only pays off in relatively well-structured areas (e.g., Weigand et al., 2003).

Cultural Diversity

Culture is defined as "the collective programming of the mind which distinguishes the members of one category of people from those of another" (Hofstede, 1984 p. 389). Prior research indicates that negotiation styles differ from culture to culture. Indeed, culture may influence how negotiators conceive the very nature and function of negotiation. As individuals are formed into a negotiating team, their cultural traits are naturally aggregated; this invokes the construct of cultural diversity. Cox (1994) defines cultural diversity as the representation, in a social system, of people with distinctly different group affiliations of cultural significance.

Conceptualized as a variable gauging the cultural composition of a team, cultural homogeneity and heterogeneity are the two possible conditions assumed by cultural diversity. Lau and Murnighan (1998) define a homogeneous team as one in which all members perceive themselves as sharing key salient characteristics; they define heterogeneity as the number of distinguishable subgroups that a team's members perceive on the basis of salient characteristics. As far as the determinants of perceived heterogeneity are concerned, researchers have proposed specific hierarchies of traits and nationality is widely considered the most salient dimension in determining heterogeneity (Earley & Mosakowski, 2000).

Figure 1. Research Model



RESEARCH MODEL AND HYPOTHESES

Figure 1 depicts our research model. The foundational proposition is that the level of NSS impacts on the extent of coalition formation within a negotiating team, which is the primary dependent variable of our study. In addition, level of NSS through altering coalition formation dynamics also has consequences for various aspects of negotiation outcomes, which are the secondary dependent variables (as represented in dotted box and arrow). Cultural diversity is conceptualized as the antecedent of coalition formation.

Level of NSS, Extent of Coalition Formation, and Negotiation Outcomes

In line with previously attempted conceptualization of NSS (Lim & Benbasat, 1993), two levels of NSS are prominent. Level-1 NSS provide basic support for electronic communication within a negotiating team and also between opposing parties. Level-2 NSS comprise both electronic communication and DSS. As far as inter-team negotiation is concerned, consensus within a negotiating team before any exchange of offers with the opposing party is deemed necessary. Therefore, on top of level-2 NSS which could be sufficient for interpersonal negotiations, we make extension to the traditional framework and further conceptualize level-3 NSS which facilitate decision making within a negotiating team by employing the Delphi technique (see Anderson, 1990).

DSS have been known to aid negotiators in overcoming their cognitive limitations and in identifying their and others' real interests (Fisher & Ury, 1983). DSS assist individuals in forming objective representation of negotiation situations and in generating prescriptions about what to do during a negotiation (Starke & Rangaswamy, 1999). As members of a negotiating team develop more objective understanding of the negotiation situation, their definitions of the negotiation problem converge. The particular assumptions and values associated with social categories are filtered to a large extent. Furthermore, while DSS promote a task-related rather than socio-emotional focus, the social-psychological processes associated with group faultlines are less likely to materialize. In this case, it is of lower possibility that a coalition

will form between certain members. We have the following hypothesis.

Hypothesis H1a: The extent of coalition formation within a negotiating team will be lower when assisted by level-2 NSS than by level-1 NSS.

In addition, we posit that level-3 NSS involving the Delphi technique will further lower the extent of coalition formation compared to level-2 NSS. The Delphi technique alters the team process to be a statistical aggregation of individual decision making which minimizes the interaction among team members. Furthermore, the anonymous mechanism reduces evaluation apprehension and conformance pressure. Minimum team interaction and anonymity hinder group faultlines from taking effect, and hence render coalition formation very unlikely if possible.

Hypothesis H1b: The extent of coalition formation within a negotiating team will be lower when assisted by level-3 NSS than by level-2 NSS.

Hypothesis H1c: The extent of coalition formation within a negotiating team will be lower when assisted by level-3 NSS than by level-1 NSS.

Through altering the dynamics of coalition formation, the level of NSS, also impacts upon various aspects of negotiation outcomes. Lau and Murnighan (1998) pointed out that unspoken but implicit subgrouping (coalition formation) limit cross-subgroup communication and as the notion of in-groups and out-groups gets perpetuated, conflict between subgroups increases, which in turn may create hostility between these subgroups, thus leading to lower cohesion perceived by team members. Cohesion is associated with performance and satisfaction. As the cohesion of a negotiating team gets harmed, the negotiation performance and members' satisfaction will be downgraded accordingly. As the negotiation outcome of one party is compromised, the joint outcome will also be lowered. In addition, when a team is divided into coalitions, the processes that members typically go through to reach consensus will be hindered as communication and task interdependence are hurt (Clark et al., 2000). While the negotiating team takes more time to reach consensus among the members, the total negotiation time lengthens. Joint outcome and negotiation time are directly linked to members' satisfaction as well. Through intervening with the extent of coalition formation, the level of NSS has consequences for the aforementioned negotiation outcomes as hypothesized below:

Hypothesis H2a: The cohesion of negotiating team is higher when assisted by higher level NSS.

Hypothesis H2b: The joint outcome is higher when assisted by higher level NSS.

Hypothesis H2c: The negotiation time is shorter when assisted by higher level NSS.

Hypothesis H2d: Members' satisfaction is higher when assisted by higher level NSS.

Antecedent of Coalition Formation: Cultural Diversity

Negotiators with similar cultural traits tend to define negotiation situation similarly (Salacuse, 1991). Psathas and Stryker (1965) suggest that coalitions stabilize as people develop similar definitions of their task situation, i.e., coalition members tend to be those who ultimately define the situation similarly. From the faultline perspective, culture constitutes a salient faultline to activate subgrouping process in a negotiation context. Members of similar cultural traits, based on various cues, may identify with each other and categorize themselves as a subgroup. With the implicit formation of the coalition, its members act according to their acknowledged prototypes, balanced by a concern to represent their in-group

favorably, and hence perpetuate the coalition. A negotiating team with a heterogeneous-cultural setting is especially prone to such phenomenon, as similarity in cultural traits presents itself as a strong criterion for forming coalitions.

Hypothesis H3: The extent of coalition formation is higher in teams characterized by heterogeneous culture than in those characterized by homogeneous culture.

RESEARCH METHOD

Experimental Design

We utilized a laboratory experiment to test our hypotheses. Forty-eight students were recruited from a large university in Singapore as subjects. All of them were from mainland China with Mandarin as their native language. However, they were proficient in English conversation. The experiment adopted a 3x2 factorial design in line with the two independent variables in our research model, i.e., level of NSS and cultural diversity. There were three experimental conditions distinguished by the NSS level. Each condition was assigned eight negotiating teams with three members (one of them is a confederate) per team, which underwent four inter-team negotiation sessions. The subjects involved in the negotiation session scoring the highest joint outcome within each condition were given monetary rewards.

Level of NSS was manipulated by providing distinct levels of NSS support for different treatment conditions. Level-1 NSS providing electronic communication channels were realized through commonly used instant messaging software (ICQ and MSN). Level-2 NSS employed similar electronic communication channels, on top of which decision support systems (DSS) catered specifically towards negotiation were put in place. Traditional DSS embedded in NSS encompass two components: contract evaluator and generator (see Foroughi et al., 1995 for an example). Contract evaluator supports the evaluation of contracts based on the preset preference scores of the negotiator. Contract generator supports the generation of possible concessions and solutions. Based on one party's preset point structure and the estimated point structure of the opposing party, it will generate all possible contracts and display the contract(s) leading to the highest joint outcome. The two major components aforementioned had both been implemented in our DSS. Level-3 NSS availed all the functions of level-2 NSS, plus the incorporation of Delphi technique. The technique was implemented in level-3 NSS so that members of a negotiating team first input the offers they deemed most sensible for the current round of exchange with proper reasoning. All members then proceeded to vote on these suggested offers. Such procedure iterated until there emerged one with the majority of votes as the finalized offer for the current exchange.

Cultural diversity in our study was operationalized through composition of nationalities and manipulated via the scripting of confederates. Since all actual subjects were from mainland China, a homogenous-cultural negotiating team involved a confederate playing a student of the same origin. On the other hand, a heterogeneous team included a confederate negotiator of a different nationality, in this case Singaporean. As all negotiation sessions were conducted electronically with communication channels enabling mainly text, language was deemed an appropriate index of culture to manipulate the cultural diversity of teams.

It is suggested that Singapore's unique English style, which is the shared language of Singaporean society, reflects its unique culture. For instance, there is extensive use of discourse particles and interjections (e.g., ah, lah, what, and ai-yah) in Singapore English. Wee (1998, p. 191) points out that these "exclamations and particles … convey attitudes and emotions, and are often seen as lexical items which are most uniquely Singaporean". In our experiment, the confederates' cultural

Table 1. Coding Scheme

Main Aspects	Categories	Examples
Social-emotional aspect: *positive reactions*	Shows solidarity, raises other's status, offers compliment, gives help	"I can see how you feel," "You've done a good job," "That's fine."
	Shows tension release, cracks jokes, expresses laughter, shows satisfaction	"Great, we have finally worked it out," "lol," (stands for "laugh out loudly" in virtual chat), "I am pleased with that."
	Shows agreement, shows passive acceptance, displays understanding, gives affirmation, expresses compliance	"Yes, that's it," "Then I guess we're all agreed on that," "I think you are right about that," "Let's do that."
Social-emotional aspect: *negative reactions*	Raises disagreement, shows passive rejection, displays formality, withholds help	"I don't think that will work," "Are you sure?" "How I wish that is the case!"
	Shows tension, seeks help, displays withdrawal	"That's my fault indeed," "Oh mine, what can we do now?" "There's nothing much we can do in this case."
	Shows antagonism, deflates other's status, defends or asserts self	"Stop that!" "See what an idea you have suggested," "I've tried my best though."
Task aspect: *attempted answers*	Gives suggestion, direction, implying autonomy for other	"Shall we start with an offer that's best for us?" "We'd better make compromises little by little so as not to miss any better deal."
	Gives opinion, evaluation, analysis, expresses feeling, wish	"I think that might be a good deal," "So far, the buyer has been compromising only on price," "I feel they will accept our offer this time."
	Gives orientation, information, makes repetition, offers clarification, gives confirmation	"I have just double checked—our bottom line is 44 scores," "What I meant was actually to wait for their offer first."
Task aspect: *questions*	Asks for orientation, information, repetition, confirmation	"Where are we now?" "What's our score if we accept the offer?" "I did not really get you."
	Asks for opinion, evaluation, analysis, expression of feeling	"How long do you think they will take to pose an offer?" "What do you think of their offer?" "What strategy are they using?"
	Asks for suggestion, direction, possible ways of action	"Which issue shall we concede on first?" "What is our general strategy?" "What can we do now to improve our outcome?"

backgrounds could hence be discriminated by the jargon they use (Romaine, 1994). A standardized script embedding cultural diversity conditions was crafted to be used by confederates in homogeneous and heterogeneous sessions respectively. There was one question in the post-experiment questionnaire probing subjects' perceived level of cultural diversity. Results showed that cultural diversity was successfully manipulated ($p = 0.008$).

The extent of coalition formation has not yet been operationalized in extant literature. Due to the dynamic nature of the variable, it is insufficient to be measured in a post-experiment questionnaire alone. Therefore, we took the approach of content analysis, which has been widely adopted in negotiation studies. During each negotiation session, all inputs made by the negotiators, including the subjects and the confederate, were logged. The coding scheme proposed by Bales (1950) was adapted to analyze the negotiation sessions (see Table 1).

A mathematical index was constructed as in the subsequent formula to quantify the extent of coalition formation. As the confederates were employed to manipulate the cultural diversity conditions, we were only examining the extent of coalition

formation between the other two members in a team, which is reflected in the formula.

$$Coalition\_Rate = \frac{PR(sub1 \rightarrow sub2) + PR(sub2 \rightarrow sub1)}{PR(sub1 \rightarrow con) + PR(sub2 \rightarrow con)} \times \frac{NR(sub1 \rightarrow con) + NR(sub2 \rightarrow con)}{NR(sub1 \rightarrow sub2) + NR(sub2 \rightarrow sub1)}$$

Essentially, the relative frequency of positive and negative reactions between two members is considered a representative indicator of the extent of their coalition formation. In the above formula, *PR* indicates frequency of positive reactions, while *NR* indicates frequency of negative reactions. *PR(sub1→sub2)*, thus, represents the positive reactions from subject 1 to subject 2. In the same vain, *NR(sub1→con)* denotes the negative reactions from subject 1 to the confederate.

The negotiation-outcome-related variables were measured as follows. Cohesion of negotiating team and members' satisfaction were both measured through subjects' responses to questionnaire items, which were verified by Evans and Jarvis (1986) and Foroughi et al. (1995) respectively. Joint outcome was calculated as the sum of utility scores for both buyer team and seller team achieved from the final agreement. Negotiation time was measured in minutes, from the time when the negotiation session was started till the moment that final agreement was reached.

Experimental Task and Procedure

Negotiating teams in all conditions performed the same negotiation task. The task chosen for this experiment involved negotiation between a buyer team and a seller team over four issues – unit price, purchase quantity, time of first delivery, and warranty period – of a three-year purchase agreement for an engine subcomponent (Jones, 1988). The negotiation case was characterized as low-conflict with different weights assigned to the issues, creating a bargaining situation in which mutually beneficial trade-offs were possible. The negotiation case included a BATNA (Best Alternative to Negotiated Agreement), represented as an alternate offer from another company, which provided the negotiating teams with a minimum point level to achieve.

Subjects were randomly assigned to the experimental conditions, the roles of buyer and seller, as well as the specific negotiating teams. They were briefed online prior to their respective negotiation sessions and sent electronic versions of the general instructions, case description (including private information for buyer and seller such as their preference structure) and training materials for their designated levels of NSS. Subjects were given sufficient time to go through the materials and encouraged to clarify any doubts they had. Afterwards, they filled out a short pre-experiment questionnaire mainly measuring their demographics. The questionnaire also included a short quiz justifying their understanding of the case and proficiency in using the systems.

Subjects were required to log into their designated systems during assigned time slots. The experiment coordinator oversaw each experimental session to make sure all regulations were properly observed and in the meantime logged the sessions. There was no time limit imposed upon any negotiation session. The closure of any session was symbolized by the buyer and seller teams both agreeing to one common contract. Upon settlement, subjects were asked to complete a post-experiment questionnaire. Before logging off the systems, subjects were reminded explicitly not to reveal any details of this experiment to any others.

EMPIRICAL FINDINGS AND IMPLICATIONS

This section reports the empirical results derived from the laboratory experiment and discuss the theoretical and practical implications that can be drawn from the findings.

Table 2. Two-way ANOVA for Coalition_Rate

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	7.290(a)	5	1.458	2.891	.044
Intercept	39.015	1	39.015	77.358	.000
NSS_Level	4.395	2	2.198	4.357	.029*
Cultural_Diversity	2.640	1	2.640	5.235	.034*
NSS_Level * Cultural_Diversity	.255	2	.128	.253	.779
Error	9.078	18	.504		
Total	55.384	24			
Corrected Total	16.369	23			

Dependent Variable: Coalition_Rate
a R Squared = .445 (Adjusted R Squared = .291)
* Significant at the .05 level.

Empirical Findings

All the subjects' transcripts were coded and analyzed. Before the actual coding, two raters came to consensus upon the understanding of the coding scheme. Both of the raters then coded a portion of the transcripts together and resolved most of the differences on the spot, which implies an 86.8% reliability of the coding results for the rest of the transcripts coded by one major rater. Two-way ANOVA (see Table 2) was conducted to test the main effect of level of NSS and cultural diversity. The results show that level of NSS does exhibit a significant impact upon the extent of coalition formation within a negotiating team. However, the post-hoc pairwise analysis (Table 3) shows partial support for the first set of hypotheses in that H1a is supported while H1b and H1c are not. We have spotted some particular behavior as major cause for such finding: voluntary leadership vs. dominant behavior. On the other hand, results show significant support of H3 concerning cultural diversity as the antecedent of coalition formation.

In the experiment, there was no pre-designated leader for any negotiating team. However, it was observed in some teams the emergence of leadership. An effective leader may help to keep the team focusing on the task and make sure all

Table 3. Post-hoc Pairwise Analysis

(I) NSS_Level	(J) NSS_Level	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1.00	2.00	.99875	.37755	.049*	.0046	1.9929
	3.00	.22375	.37755	.840	-.7704	1.2179
2.00	1.00	-.99875	.37755	.049*	-1.9929	-.0046
	3.00	-.77500	.37755	.147	-1.7691	.2191
3.00	1.00	-.22375	.37755	.840	-1.2179	.7704
	2.00	.77500	.37755	.147	-.2191	1.7691

Dependent Variable: Coalition_Rate Scheffe
* Significant at the .05 level.

Table 4. Means of Outcome Variables with Level of NSS (s.d. between brackets) and Significance Level

Outcome Variables	Scale Unit	Level-1 NSS	Level-2 NSS	Level-3 NSS	Significance Level (p)
Cohesion of negotiating team	Individual subject	6.20 (0.49)	6.05 (0.54)	6.12 (0.68)	0.791
Joint outcome	Negotiation session	125.00 (1.83)	126.50 (5.20)	131.25 (2.06)	0.110
Negotiation time	Negotiation session	83.75 (4.72)	67.75 (5.12)	57.00 (28.58)	0.181
Members' satisfaction	Individual subject	6.20 (0.69)	5.80 (0.78)	6.39 (0.44)	0.051

team members participate collaboratively. For instance, Jim (fake name is used to protect the true identity of the subject) played the role of buyer in a cultural-heterogeneous team with level-1 NSS support. Every time the seller team provided a new offer, Jim would calculate the utility score for their side first. After analyzing the situation, he shared his ideas with his teammates, and asked for everyone's suggestions. Thus, everyone in the team had a chance to participate within a collaborative atmosphere. Consequently, in spite of being a heterogeneous team, it experienced a much lower extent of coalition formation than teams in the same condition. Moreover, the negotiation outcomes were better.

In contrast to such constructive leadership, dominant behavior in certain teams has not only altered the dynamics of coalition formation but also hindered the teams from achieving better outcomes. Specifically, some negotiators were extremely defensive of their own opinions and very determined to persuade their teammates. For example, Frank (fake name is used to protect the true identity of the subject) played the role of seller in a cultural-heterogeneous team with level-2 NSS support. He tried to persuade others to accept his suggestion of conceding on the issue of highest priority to them. His purpose was to confuse the opposing party, and to make sure that its members did not know which issues Frank's team cared about the most. However, his suggestions, being rather extreme, were not conformed to by other teammates. Therefore, the extent of coalition formation was much lower compared to other teams in the same condition. The low extent of coalition formation, though, did not spare the team from unsatisfactory negotiation outcomes, especially in perceived cohesion of the team.

Two-way ANOVA has also been used to test the negotiation outcomes with respect to different treatment conditions (see Table 4 for the summary of results). Joint outcome and negotiation time are not significantly distinguished between conditions. Nonetheless, the exhibited directions of mean values for both joint outcome and negotiation time are as hypothesized. Level of NSS is not shown to be significantly associated with perceived cohesion of negotiating team. Comparison of means shows unexpected result in that teams with level-2 NSS exhibit lowest level of perceived cohesion. Members' satisfaction is shown to exhibit marginally significant difference ($p = 0.051$) with distinct levels of NSS support. However, similar to perceived cohesion, mean value of level-2 NSS condition has contradicted our hypothesis. With a careful analysis of the negotiation sessions, we have attributed the findings concerning members' perceived cohesion of negotiating team and satisfaction to scripts of novice negotiators and their appropriations of NSS.

Scholars have long suspected that people have scripts that guide their negotiation behavior. For

example, it is found that novices tend to assume that negotiating parties' interests are incompatible and that negotiation is characterized by sequential issue settlement. The scripting behavior was also seen in our experiment where a good portion of subjects was extremely concerned with price and considered it impossible to reach a deal without conceding on price.

The novice scripts seem to have affected subjects to various extents and led to different appropriations of the systems at hand. Some subjects internalized the "spirit" of always evaluating the four issues as a whole package and thus better utilizing the decision support systems. Other subjects, however, stuck to their novice scripts and hence had not taken full advantage of the provided systems. The different appropriations of the systems introduced another source of conflict among team members; this phenomenon was particularly salient with the contract generator. Some subjects were not able to appreciate the function due to their limited understanding of joint outcome, for instance. That is plausibly why the means of perceived cohesion of negotiating team and members' satisfaction were found to be lowest in level-2 NSS condition. While level-3 NSS resulted in better outcomes, this could be attributed to the enforcement of Delphi technique which further structured the team interaction process.

Implications

Based on the empirical findings, the following implications can be drawn. Theoretically, as extant literature on NSS has almost exclusively addressed technology's intervening role in interpersonal negotiations, how NSS support inter-team negotiations has remained under-explored though they have gradually become the norm in business negotiations. The current study represents a pioneering effort in this light; the preliminary findings indicate favorable use of NSS in such settings. Three levels of NSS are conceptualized, of which the first two levels correspond to the theoretical components suggested for traditional NSS. However, the theoretical foundation we have resorted to in explaining the role of NSS is distinct from previous literature, especially via its invocation of coalition formation. The third level of NSS extends the conceptualization from prior attempt, and specifically caters towards inter-team negotiations. Its potential in improving negotiation process and outcomes has been illustrated by the experimental results.

The study has the following practical implications. Although a number of commercial NSS packages are available for sale, practical usage of NSS in organizations has been minimal. The study has highlighted the potential of NSS in influencing coalition formation within a negotiating team, which could help better organizational effectiveness. This is especially relevant as inter-team negotiations become commonplace and new forms of organizations have to accommodate more organizational tasks completed via electronic communication. As cultural diversity has become a reality in organizations, mechanisms for circumventing its negative consequences would be welcome. This study has targeted the important element of coalition formation.

CONCLUDING REMARKS

The current paper represents an exploratory step of this new phenomenon, the effectiveness of NSS on inter-team negotiations through intervening with coalition formation dynamics. It has the following limitations, which open up avenues for future research. First, similar to most prior NSS studies, we have looked exclusively into the stage of negotiation dance (see Lim, 1999 for a discussion on the multiple stages of a negotiation episode). We have reasons to believe though, that the findings derived from this core phase will be more pronounced in a more comprehensive negotiation setting, which is to be verified in future studies. Second, cultural diversity is by no

means the only antecedent of coalition formation in a negotiating team. Nevertheless, to facilitate an initial effort and to maintain the parsimony of our research model, we leave the examination of other related factors to future research.

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Chapter 21
Impact of Age on Information Technology Salaries

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ABSTRACT

The Equal Employment Opportunity Commission of the United States of America reported in 2002 that age discrimination was its fastest-growing complaint. This chapter examines the treatment of information technology professionals using the Human Capital Model. The model results suggest that age treatment discrimination exists but varies across industries and job functions. The authors present explorative theories to explain why such variations exist and draw managerial implications based on the results.

INTRODUCTION

In a tough economic environment, managers are often forced to reduce employment and older workers are often the easy targets. Accordingly, discriminating practices based on age is more widespread than ever (Lucas & Keegan, 2008). Specifically, the Equal Employment Opportunity Commission (EEOC) of the United States of America (U.S.A) reported in Fiscal Year 2008, that the EEOC received 24,582 charges of age discrimination, which represents an increase of almost 74% over 1999. The EEOC resolved 21,415 age discrimination charges in FY 2008 and recovered $82.8 million in monetary benefits for charging parties and other aggrieved individuals (not including monetary benefits obtained through litigation). A March 11, 2009 Wall Street Journal article (Levitz and Shishkin, 2009) shows that overall employment discrimination complaints are also at a record high -- up 15% to 95,402 complaints -- the most dramatic increase was in the age-related complaints, the EEOC said. In the case of the Lawrence Livermore National Laboratory in Livermore, Calif., where in recent weeks at least 98 laid-off employees have filed complaints with that state's Department of Fair Employment and Housing and the EEOC, alleging that they were

DOI: 10.4018/978-1-60566-768-3.ch021

targeted in a mass layoff because of their age. (Levitz and Shishkin, 2009)

The age discrimination lawsuit brought by a 54 year former employee against Google just before its highly publicized initial public offering (IPO) highlights the issue (USA Today, 2004).

The state appeals court in California has reinstated an age-discrimination lawsuit against Google Inc. that was brought by a former technology manager who claimed Google fired him because he was not a "cultural fit." (Rosencrance, 2007). Further, older workers say they get little encouragement from their firms to keep working and have been denied promotion opportunities (The Conference Board, 2003).

By no means is age discrimination found only in the U.S.A. In fact, managers in other parts of the world seem more candid about admitting that they engage in discriminatory practices. For example, a recent survey in the United Kingdom revealed that as many as six out of ten employers prefer not to recruit staff beyond the age of 35 and that up to 40 per cent of companies admit to practicing ageism (OECD, 2002). Further, older workers are often discriminated against in the recruitment processes through the implicit or explicit use of age limits in specific occupations.

Like other forms of discrimination, age discrimination is classified as either access or treatment (Levitin, Quinn, and Staines, 1971). Access discrimination occurs when members of a certain age are not hired into certain jobs because of policies and procedures (written or unwritten) that bar their recruitment. Treatment discrimination, on the other hand, occurs when qualified members of a certain age group (usually older workers) receive lower salaries, lower status, or lower positions than comparable members of a different age group. It represents a situation in which the treatment of employees is based more on their subgroup membership than on their merit or achievements (Greenhaus, Parasuraman, and Wormley, 1990; Moyes Williams, and Quigley, 2000). It is difficult to obtain first hand data to prove access discrimination because recruiters are unlikely to openly admit that their hiring decision was based considerably on age (Gregory, 2001). Unlike proving access discrimination, it is easier to prove treatment discrimination because of the availability of salary, job qualification (such as experience and degree), and job performance (such as personnel evaluations) data.

This paper investigates age treatment discrimination exemplified in the Information Technology (IT) workforce. The reasons for focusing on the IT workforce are twofold. First, the IT industry is one of the most important and dynamic sectors in the economy. Second, it is due to data availability. We provide an exploratory assessment using salary differences between younger and older groups while controlling for experience and education. The data used for our analysis is from an on-line employment survey at Dice Incorporated (www.dice.com).

The paper is organized as follows. We begin with a review of the relevant literature on age discrimination. Then, we review the methodology used which is based on the economic theory of human capital. After this, we address treatment age discrimination in the following order: (1) we briefly discuss the nature of the on-line survey; (2) we fit the human capital model to our entire survey data set and discuss the results; and (3) we fit the human capital model and discuss the results for specific industries and job types. The paper ends with our managerial implications and conclusions.

AGE DISCRIMINATION

According to the United Nations, ageing is increasingly becoming one of the most salient social, economic and demographic phenomena of our times. It is estimated that by 2050, the number of people over 60 in Europe will have doubled to 40 per cent of the total population or 60 per cent of the working age population (Toyne, 2002). In

the U.S.A., in the early 1900s, less than 10 per cent of U.S.A. citizens were 55 years old or older; according to the 2000 U.S.A. Census, the figure now stands at 21 per cent.

Negative stereotypes of older employees have existed for years. For example, many assume that as an employee ages, their productivity declines. Such assumptions have been used to justify age limitations on hiring, mass dismissals of middle-aged employees, and mandatory retirement of older employees (Gregory, 2001). Negative perceptions of ageing are expressed in these six common stereotypes (Gregory, 2001):

1. Older employees are stubborn, inflexible, resistant to change, and less likely to accept new technology.
2. Older employees are less productive than younger employees.
3. Older employees are less adaptable, and, as they are slow learners, they find it more difficult to retain new skills.
4. The cost of employee benefits for the older employees is greater than those for the younger employees.
5. Older employees are eager to retire at the earliest opportunity. They have an eye to retirement and merely want to ride out what remains of their careers.
6. Because their remaining tenure with the company will probably be short, it is economically unreasonable to invest in training older employees in new technologies and processes.

Further, negative perceptions may actually lower management's expectations of older employees, thus, adversely affecting employee motivation. If older employees are perceived to be inflexible and less productive and younger employees are perceived as fresh, eager, highly motivated, and trainable, the stereotype may become self-fulfilling. Stereotypical thinking creates vicious cycles that culminate in the perpetuation of age stereotypes (Gregory, 2001). Age and experience, which elsewhere gets people promoted, are no help in the Silicon Valley; on the contrary, there is a distinct bias in favor of youth (Economist, 1997). For example, a Computerworld study of Information Technology Professionals (ITP) age 30 and older reported that it took them 50 per cent longer than employees younger than 30 to find a job (King, 2002b).

Age treatment discrimination has been a common practice of U.S.A. businesses for years (Segrave, 2001). Substantial evidence supporting the hypothesis that job opportunities in many industries decline with age has been presented by Hutchens (1988). Recognizing this problem, the U.S.A. government enacted the Age Discrimination in Employment Act (ADEA) in 1967 and the Age Discrimination Act (ADA) in 1975. The ADEA and ADA are intended to end compulsory retirement and eradicate other age-related acts affecting the employment relationship. But, the ADEA failed to resolve these issues.

Nonetheless, in the past twenty years, federal and state courts, the Equal Employment Opportunity Commission (EEOC), and various state fair-employment-practice agencies have been inundated with employment discrimination cases. Between 1970 and 1989, the number of fillings of employment discrimination cases in the federal courts increased almost 2,200 per cent, while all other types of cases rose 125 per cent. Not least among these job discrimination cases were those advancing allegations of age discrimination. While the number of race, sex, and other discrimination cases is not expected to rise significantly in the near term, a massive increase in age cases appears to be on the horizon. (Gregory, 2001)

There are also proposed legislations in at least thirteen states that would make it illegal for a boss to bully an employee in the course of employment. The statutes are meant to expand existing harassment laws in such areas as race, sex, and age discrimination. (Mazurak, S. A. (2008).

In Europe, it was not until the beginning of

the 1990s when the European Union (EU) began to look into the task of guaranteeing older people a legitimate place in society and unlimited protection of their civil rights by combating discrimination based on age and social exclusion. The EU purposely pointed out that older people are particularly prone to discrimination not only in working life but in everyday life in general. In 1998, Article 13 of the Treaty of Amsterdam was introduced to complement existing powers to tackle discrimination against people on the grounds of specific characteristics such as age, gender, race and so on (Declaration of Principles, 1993). Age discrimination, however, still remains a problem in Europe. According to a 2001 poll for Age Concern conducted by a London based research firm, 70 per cent of people in the United Kingdom believe that age discrimination occurs. Further, 22 per cent reported experiencing age discrimination first-hand (ICM Research/Age Concern, 2001).

The special characteristics of the present IT job market place many older employees at a disadvantage. First, given the current tight job market, employers prefer to hire less expensive employees who are generally younger and less experienced. Second, since the knowledge needed to work in the IT field changes rapidly, younger employees are more likely to have the most current knowledge and skills if older employees do not make efforts to update their skill. Third, the time commitment and variable work hours required of ITP (Carver, 2000) particularly favors young single employees who are less likely to have heavy family responsibilities. Fourth, the trend of the IT workforce is moving towards temporary employees who have the exact vendor-specific brand and type of training needed to solve an immediate problem and their employment lasts until the problem is solved (Carver, 2000). Employers often do not provide benefits, such as training, health care, and retirement benefits, for temporary employees. These benefits are likely to be valued much more by older workers than by younger workers. Further, temporary employment may often require extensive travel which is very difficult for employees with family responsibilities. Fifth, management expectations and public perceptions of IT jobs also serve as barriers to deter older workers from entering the field or offering disincentives for them to stay in the field. The IT sector has an image of employing young workforce: older people (cited as 35 years and over) are perceived as "having lower technical skills and being techno-phobic" (Department of Education and Employment, 2001). A study by Galup, Dattero and Quan (2004) provided an empirical validation of age discrimination in computer programmer wages. They found that workers older than 40 were not equally paid as their younger counterparts when controlling for human capital factors such as education and experience.

METHODOLOGY

Typically, there are three perspectives for studying discrimination: economic, sociological, and psychological (Truman and Baroudi, 1994). In this paper, we investigate age treatment discrimination from an economic perspective. Truman and Baroudi (1994) state that the "economic perspective attempts to explain discriminatory practices, e.g., wage and job-level inequalities, by viewing individuals in terms of human capital and addressing differences in capital formation as explanatory factors behind inequalities." In this context, age discrimination means that age, rather than job-related and performance-related factors, is being used to determine who is rewarded (Truman and Baroudi, 1994).

The dominant economic theory of wage determination is the human capital theory (Berndt, 1991). Its roots date as far back as the 18th century writings of Adam Smith (1937) on equalizing or compensating for differences in wages paid to employees based on amenities and risks in the workplace. The human capital implications of

education are a well-known and straightforward extension of Smith's idea of equalizing differences (Berndt, 1991). Educated employees are (hopefully) more productive than their less educated counterparts and thus are more likely to command higher wages. This also provides an economic explanation as to why a person will forego earnings and incur additional expenses to undertake an education since there is an expectation that their efforts will result in substantially more compensation in the long run. Important early contributors to human capital theory include Becker (1962, 1964), Mincer (1957a, 1957b, 1962), and Schultz (1961). Examples utilizing human capital theory to investigate various forms of discrimination include Ang, Slaughter and Ng (2002), Lobel and St. Clare (1992), and Xia and Kleiner (2001).

For the most part, the econometric literature on wage determination has been based on regression models of the following form: the natural logarithm of earnings is a function of a measure of schooling, a measure of experience, possibly other factors, and a random disturbance term. This is based on Roy's (1950) research in which he related earnings distributions to the distributions of the underlying abilities (such as intelligence, physical strength, etc.). In addition, Roy (1950) showed that if each of the underlying abilities is normally distributed than the logarithm of earnings will be normally distributed.

Later work by Mincer (1974) showed the regression equation for the logarithm of wages is linear in education but quadratic in experience. That is:

$$\log Y_i = \log Y_0 + \beta_1 S_i + \beta_2 X_i + \beta_3 X_i^2 + u_i \quad (1)$$

where Yi is the wages for the i-th employee; Y_0 is the intercept term in the regression model which determines the base rate without education or experience; β_1 is the rate of return for education; S_i is the measure of educational attainment (in years) for the i-th employee which is simply the highest grade attended, for example, 16 years indicates a bachelor's degree; X_i is the years of experience for the i-th employee; β_2 and β_3 are coefficients that assess the rate of return on experience; and u_i is the random disturbance associated with the i-th employee. Based on human capital theory, the wages function is concave in experience because as experience increases, earnings cannot increase indefinitely. That is, there is a maximum wage that can be reached. So, estimates of β_2 should be positive while estimates of β_3 should be negative. Dattero, Galup and Quan (2005) adopted the same methodology to assess wage differentials between male and female software developers.

When considering the presence of age factor, (1) can be modified by adding a dummy variable that indicates whether the individual belongs to which age group. For our analysis, we have added 4 indicator variables: D_1, D_2, D_3, and D_4 for the age groups 25-29, 30-39, 40-49, and 50-59, respectively, where group 18-24 is used as the base. Because of the small number of respondents in the age groups under 18 and over 60, they are excluded in our analysis. The resulting human capital model is given below in equation (2).

$$\log Y_i = \log Y_0 + \beta_1 S_i + \beta_2 X_i + \beta_3 X_i^2 + \beta_4 D_{1i} + \beta_5 D_{2i} + \beta_6 D_{3i} + \beta_7 D_{4i} + u_i \quad (2)$$

In evaluating the human capital model, some reservations must be expressed concerning its application (Berndt 1991): (1) "wage determination may reveal only a portion of the total compensation differentials among employees", (2) "it is often difficult to obtain accurate data on hours worked by salaried people", and (3) "the practicing econometrician in labor economics is typically forced to make use of data that are considerably less than ideal" (Berndt does add that "in spite of these serious measurement problems much has been learned concerning the determinants of wages").

Table 1.

Scale	Experience (years)
0.5	<1
1.5	1-2
4.0	3-5
8.0	6-10
12.5	11-14
17.5	>15

RESULTS

The results presented here are based on a voluntary web-based survey on salary and skills of IT employees that was conducted by Dice Incorporated. During the period, June 7, 2000 to April 13, 2001, 22,488 full-time U.S.A. ITP completed the on-line survey.

Overall Human Capital Model

Mincer (1974) showed that the regression equation for wages is linear in education after transforming wages by a natural log but quadratic in experience as given in (1). Berndt (1991) suggested that rather than using annual salaries, the hourly salary rate should be employed. Since the respondents also indicated the average number of hours worked per week, we fit the human capital model by taking the annual salary and dividing it by the estimated hours worked per year. The estimated hours worked per year are the number of weeks per year (365 / 7) times the average hours worked per week. Note that the wage units are dollars per hours.

Rather than giving their experience in years, the respondents indicated a technical experience level. In addition, the respondents indicated their highest education level rather than number of years of education. Experience and education were scaled as shown in Table 1.

In the results presented, the coefficients will be referred to as the base (intercept term), education (β_1), experience (β_2), experience_squared (β_3), age group 18-24 (β_4), age group 25-29 (β_5), age group 30-39 (β_6), age group 40-49 (β_7), and age group 50-59 (β_8). In our regression, age group 18-24 is used as the base.

Table 2 presents the overall results for the human capital model. The model and each coefficient are highly significant. As expected by the human capital model, experience has a positive coefficient while experience squared has a negative coefficient. Age group 30-39 has the highest positive salary bias (0.122) followed by the Age Group 40-49 (0.112), the Age Group 50-59 (0.032) and the Age Group 25-29 (0.016). This clearly suggests that there is wage discrimination towards older employees in the IT industry when compared to the most favorite age group 30-39. The result also indicates that the youngest ITP groups (20-24 and 25-29) appear to be the "best value" for the same education and experience levels.

One problem with these regressions is that age and technical experience are correlated. In our case, the coefficient of correlation between age and technical experience is at 0.51. To remedy this, we divided our data set into two subgroups: those under 40 and those over 40 years of age. As noted previously, our data suggests that the maximum earnings potential for IT employees is reached before age 40. There have been many other studies suggesting 40 is a good point to split employees when studying age discrimination (Cooper and Torrington, 1981; Segrave, 2001). In addition, in the U.S.A., the ADEA specifies protection measures for individuals who are 40 years

Table 2. Human capital model results with dummy variables

Coefficient or Statistic of Interest	Estimate	t-value
Intercept	1.657[a]	60.64
Education	0.067[a]	41.49
Experience	0.080[a]	37.64
Experience2	-0.003[a]	-22.64
Age Group 25-29	0.016[a]	4.05
Age Group 30-39	0.122[a]	13.53
Age Group 40-49	0.112[a]	12.73
Age Group 50-59	0.032[a]	2.91
Adjusted R^2= 0.2636 F = 1073.31[a]		

[a] $p < .01$

of age or older from employment discrimination based on age. From the results in Table 3, we can see that the younger employees benefit slightly more from education attainment (0.074) than their older counterparts (0.063) and much more from technical experience (0.096) than their older counterpart (0.061). It is also interesting to note that the intercepts are greater for the 40+ than for the 40- workers. This suggests that other intangible factors than human capital ones (such as achievement, knowledge, and social networking) play a role in determining older workers' salaries.

To determine if the difference between older and younger workers is statistically significant, we will employ the Chow (1960) test statistic:

$$F \frac{\left(RRSS - URSS\right) / \left(k+1\right)}{URSS / \left(n_1 + n_2 - 2k - 2\right)} \quad (3)$$

where URSS = (RSS40-) + (RSS40+) and RRSS = RSSall, k is the number of independent variables and n_1 and n_2 are the number of observations for age groups 40 and under and 40 and over, respectively. We calculate F = 24.59 (the test statistic is distributed according to an F-distribution with (k + 1) and ($n_1 + n_2 - 2k - 2$)) which is significant

Table 3. Human capital model results with split dataset

Coefficient or Statistic of Interest	Under 40	Over 40	Overall
Intercept	1.661[a]	1.894[a]	1.721[a]
Education	0.074[a]	0.063[a]	0.071[a]
Experience	0.096[a]	0.061[a]	0.089[a]
Experience2	-0.003[a]	-0.002[a]	-0.003[a]
Adjusted R2	0.252	0.224	0.254
F	1774.86[a]	497.61[a]	2385.02[a]
RSS	2705.72	839.63	3561.99
N	15808	5161	20969
Chow test: F = 24.59 [a]			

[a] $p < .01$

at better than the 1 per cent level, which implies that there is indeed significant difference between these two age groups. In order to show the direction of such a difference, we fit the Human Capital Model using the estimates from Table 3 and average education attainment (15.46 years) and technical experience (6.81 years) for the entire dataset. The fitted average hourly wage for the younger employees is $27.65 and for the older $24.31. That is, the employees in the age group 40 and over make only 88 per cent of their younger counterpart given the same education and technical experience levels. Therefore, the data suggest that severe age treatment discrimination exists in the IT workforce.

Treatment Discrimination and Industry

In the sociological perspective of discrimination, inequalities are the result of structural differences in society and the economy (Truman and Baroudi, 1994). The conflicting general attitude towards employment of older employees can contribute to uneven discriminatory practices across industry and job functions. On one hand, there is the stereotypical view that older employees are less creative, less adaptable, and less productive. On the other hand, others argue that older employees are more productive because of their experience and maturity (Bluestone, Montgomery, and Owen, 1990; Cooper and Torrington, 1981; Segrave, 2001). This divergence in attitudes toward older employees can lead to potentially different practices in the workplace. For example, wage inequality based on age may be explained by differences in the proportion of older to younger employment by industry and occupation, or by various characteristics of the organization such as its size and extent of unionization.

The industry sectors represented in our data set range from government to private organizations. Each sector has its own characteristics, environment, and customer-base to serve. The divergence in corporate cultures and environments lead to different business practices in general and discriminatory practice in particular. For example, the IT industry is a rapidly changing environment as opposed to more well established and relatively stable industries such as Retail and Manufacturing. The difference in their respective environments leads to different corporate cultures, which inevitably influences business practices.

In the on-line survey, a respondent could select from 19 industry categories. To simplify our analysis and presentation, these 19 categories were combined into the following 8 groups (corresponding survey categories are in parentheses): (1) Information Technology (Computer Hardware, Computer Software, Internet Services, and Telecommunications), (2) Finance (Finance), (3) Government (Government and Defense), (4) Manufacturing (Manufacturing), (5) Medical/Pharmaceutical (Medical/Pharmaceutical), (6) Wholesale/Retail (Distributor/Wholesale and Retail/Mail Order/E-Commerce), (7) Transportation/Utilities (Transportation and Utilities), and (8) Other (Agriculture, Automation, Entertainment, Non-profit, Publishing, and Other). For each industry we divide the data into two groups: under 40 years and 40 years and older.

The results are presented in Table 4. Based on the Chow test statistics, the two age groups are significantly different (at the 1 per cent level) from each other for Finance, Government, IT, Medical, and Other but insignificant for Manufacturing, Transportation and Public Utilities, and Wholesale/Retail. Therefore, there is evidence to support age discrimination in some of the sectors but not in the others. It is also evident that age discrimination does not appear to be homogenously observed in all sectors. For example, in Finance, IT and Medical sectors, the employees who are 40 years and older make less than their younger counterparts, given the same education and technical experience levels. The percentages of what 40 years or older ITP make in relation to their younger counterparts in these three indus-

tries are 87 per cent, 94 per cent and 87 per cent, respectively. It is interesting to note that older ITP fare better in Government with a wage ratio of 102 per cent. Since the "Other group" lumps together a few sectors (relevant or not), it is difficult to draw any plausible conclusions for this group. Overall, the results and analysis by sector are suggestive that age treatment discrimination does not exist homogenously in all sectors of the IT workforce.

Treatment Discrimination and Job Functions

Among different job functions, expectations and responsibilities for employees varies dramatically. For example, the major concerns of top IT management are strategic, such as plans and actions that respond to rapidly changing competitive environments. Employees at this level must have experience dealing with these types of situations and as a result are often older employees. This poses a dilemma for management. On one hand, experienced employees tend to be older. On the other hand, negative stereotypes of older employees suggest that they are not as creative, flexible and adaptive as their younger counterparts.

Job requirements for positions such as Quality Assurance (QA) Testers and Developers are different from those for top management. The job activities of a QA Tester are relatively constant and steady. Therefore, people in this position are required to be, to a large extent, detail oriented and patient but not necessarily quick to change or creative. Similarly, developers are required to be detail oriented and patient but they also may need to be adaptable and creative. The vast differences in job requirements across the entire job function spectrum no doubt influence how age discriminatory practice is conducted across job functions.

In the on-line survey, a respondent could select from 38 different job titles. To simplify our analysis and presentation, these job titles have been grouped into 10 categories of job titles. The 10 categories are (corresponding survey titles are in parentheses): (1) Top Management, (2) Strategist/Architect (IT Management – Strategist of Architect), (3) MIS Manager (MIS Manager), (4) Project Manager (Project Manager), (5) Database Administrator (Database Administrator), (6) Analyst (Analyst and Business Analyst), (7) Developer (Applications, Client/Server, Database, System and Software Engineers), (8) Web (Web Administrator, Web Designer, and Web Developer/Programmer), (9) QA (Quality Assurance Tester), (10) Support (Desktop Support Specialist, Help Desk, and Technical Support) and (11) Networking (Network Design, Network Engineer and Network Manager). The results are presented in Table 5.

The results in Table 5 reveal that the Chow test finds no significant differences between older and younger employee for three job functions: Networking, QA Testers and Strategist/Architect. Therefore, there is no evidence to support age discrimination in these job functions. For other job areas, the differences between older and younger employees are very significant (Chow test statistics significant the at 1 per cent level) for Analyst, DBA, Developer, Project Manager, Support Personnel and Top Management, and significant (5 per cent level) for MIS Manager and Web Personnel. In terms of wages, the ratios of the typical fit between older and younger ITP are all below 100 per cent except Top Management with 102 per cent. Therefore, the results above seem to suggest that age treatment discrimination does *not* exist homogenously in all job functions of the IT workforce.

DISCUSSION

The results of the study suggest the follow: (1) age discrimination exists in overall IT wages, (2) age treatment discrimination does not exist homogenously in all sectors of the IT workforce, and (3) age treatment discrimination does not

Table 4. Age discrimination by industry

	Parameters	Finance	Government	IT	Manufacture	Medical	Transportation and Public Utilities	Wholesale Retail	Other
40-	INTERCEPT	1.796 [a]	1.304 [a]	1.749 [a]	1.854 [a]	1.638[a]	1.983[a]	1.420[a]	1.663[a]
	EDU	0.072 [a]	0.093 [a]	0.071 [a]	0.061 [a]	0.072[a]	0.055[a]	0.081[a]	0.066[a]
	EXP	0.086 [a]	0.070 [a]	0.098 [a]	0.074 [a]	0.100[a]	0.085[a]	0.117[a]	0.107[a]
	EXP2	-0.003 [a]	-0.002 [a]	-0.003 [a]	-0.002 [a]	-0.004[a]	-0.003[a]	-0.004[a]	-0.004[a]
	Adj. R^2	0.261	0.244	0.255	0.231	0.269	0.288	0.327	0.241
	F value	157.70 [a]	84.64 [a]	1047.21 [a]	88.18 [a]	68.21[a]	47.72[a]	104.17[a]	223.98[a]
	Typical fit	29.07	22.62	28.55	24.37	25.99	26.29	26.74	25.16
40+	INTERCEPT	2.136 [a]	2.264 [a]	1.829 [a]	1.997 [a]	2.027[a]	2.130[a]	1.649[a]	1.962[a]
	EDU	0.052 [a]	0.041 [a]	0.068 [a]	0.061 [a]	0.063[a]	0.044[a]	0.065[a]	0.054[a]
	EXP	0.043 [a]	0.035 [b]	0.075 [a]	0.041 [a]	0.016	0.075[a]	0.095[a]	0.058[a]
	EXP^2	0.000	0.000	-0.002 [a]	0.000	0.000	-0.002[b]	-0.003[a]	-0.001[a]
	Adj. R^2	0.26	0.16	0.23	0.16	0.21	0.25	0.38	0.21
	F value	55.51v	29.37 [a]	220.23 [a]	33.84 [a]	21.87[a]	18.61[a]	55.51[a]	73.30[a]
	Typical fit	25.16	22.97	26.86	24.98	22.55	24.96	23.88	22.62
	percent 40+/40-	87%	102%	94%	103%	87%	95%	89%	90%
All	INTERCEPT	1.918 [a]	1.654 [a]	1.761 [a]	1.877 [a]	1.772[a]	2.049[a]	1.510[a]	1.753[a]
	EDU	0.066 [a]	0.072 [a]	0.070 [a]	0.062 [a]	0.066[a]	0.051[a]	0.075[a]	0.061[a]
	EXP	0.073 [a]	0.061 [a]	0.096 [a]	0.067 [a]	0.082[a]	0.080[a]	0.114[a]	0.096[a]
	EXP^2	-0.002 [a]	-0.002 [a]	-0.003 [a]	-0.002 [a]	-0.003[a]	-0.003[a]	-0.004[a]	-0.003[a]
	Adj. R^2	0.271	0.253	0.262	0.228	0.254	0.298	0.352	0.238
	F value	225.45 [a]	140.03 [a]	1352.28 [a]	136.79 [a]	90.86[a]	73.01[a]	165.68[a]	305.77[a]
Chow-tests		6.181 [a]	4.734 [a]	4.944 [a]	1.039	3.634[a]	0.359	1.881	5.081[a]

[a] $p < .01$ [b] $p < .05$

exist homogenously in all job functions the IT workforce. The first observation confirms a well known, if not admitted, fact. The other two observation offer more questions than answers -- if age discrimination is not uniformly distributed across industries and job functions, what char-

Table 5. Age discrimination by job function

	Parameters	Analyst	DBA	Developer	MIS Manager	Networking	Project Manager	QA Tester	Strategist /Architect	Support Personnel	Top Mgmt	Web
40-	INTER-CEPT	1.471 [a]	1.427 [a]	2.221 [a]	2.388 [a]	2.187 [a]	2.092 [a]	2.247 [a]	2.547 [a]	1.819 [a]	2.063 [a]	1.920 [c]
	EDU	0.084 [a]	0.094 [a]	0.047 [a]	0.033 [a]	0.045 [a]	0.054 [a]	0.041 [a]	0.031 [a]	0.057 [a]	0.054 [a]	0.058 [c]
	EXP	0.102 [a]	0.097 [a]	0.093 [a]	0.079 [a]	0.068 [a]	0.088 [a]	0.096 [a]	0.088 [a]	0.057 [a]	0.110 [a]	0.103 [c]
	EXP^2	-0.004 [a]	-0.003 [a]	-0.004 [a]	-0.003 [a]	-0.002 [a]	-0.003 [a]	-0.004 [a]	-0.003 [a]	-0.002 [a]	-0.004 [a]	-0.004 [c]
	Adj. R^2	0.247	0.292	0.210	0.167	0.150	0.233	0.240	0.115	0.129	0.234	0.151
	F value	166.26 [a]	70.48 [a]	313.97 [a]	26.29 [a]	103.61 [a]	57.44 [a]	38.48 [a]	19.25 [a]	97.74 [a]	71.81 [a]	76.01 [c]
	Typical fit	26.31	29.41	30.59	27.00	25.77	29.69	29.12	32.37	20.29	32.30	28.07
40+	INTER-CEPT	1.951 [a]	2.193 [a]	2.267 [a]	2.794 [a]	2.648 [a]	2.444 [a]	1.951 [a]	2.460 [a]	2.081 [a]	2.912 [a]	2.395 [c]
	EDU	0.065 [a]	0.044 [a]	0.045 [a]	0.015	0.014	0.056 [a]	0.065 [a]	0.036 [a]	0.037 [a]	0.019 [b]	0.035 [a]
	EXP	0.055 [a]	0.090 [a]	0.066 [a]	0.022	0.061 [a]	0.010	0.045	0.053 [b]	0.064 [a]	0.051 [b]	0.042
	EXP^2	-0.002 [a]	-0.003 [a]	-0.002 [a]	0.000	-0.002 [a]	0.000	-0.001	-0.001	-0.002 [a]	-0.001	-0.001
	Adj. R^2	0.161	0.263	0.140	0.187	0.118	0.146	0.137	0.186	0.198	0.055	0.161
	F value	41.15 [a]	24.28 [a]	46.04 [a]	16.74 [a]	19.79 [a]	20.69 [a]	7.84 [a]	14.42 [a]	52.84 [a]	10.38 [a]	9.66 [c]
	Typical fit	25.39	28.86	27.69	24.10	24.15	29.43	24.47	27.94	20.17	32.81	24.40
	40+/40- %	96%	98%	91%	89%	94%	99%	84%	86%	99%	102%	87%
All	INTER-CEPT	1.599 [a]	1.649 [a]	2.240 [a]	2.506 [a]	2.290 [a]	2.158 [a]	2.121 [a]	2.547 [a]	1.882 [a]	2.365 [a]	1.981 [c]
	EDU	0.079 [a]	0.080 [a]	0.046 [a]	0.027 [a]	0.037 [a]	0.054 [a]	0.050 [a]	0.032 [a]	0.052 [a]	0.037 [a]	0.054 [c]
	EXP	0.089 [a]	0.093 [a]	0.089 [a]	0.063 [a]	0.073 [a]	0.075 [a]	0.081 [a]	0.080 [a]	0.060 [a]	0.103 [a]	0.099 [c]
	EXP^2	-0.003 [a]	-0.003 [a]	-0.003 [a]	-0.001 [a]	-0.002 [a]	-0.002 [a]	-0.003 [a]	-0.002 [a]	-0.001 [a]	-0.003 [a]	-0.003 [c]
	Adj. R^2	0.233	0.3029	0.2011	0.1832	0.1435	0.2262	0.1941	0.1377	0.1645	0.1778	0.1556
	F value	218.18 [a]	102.67 [a]	367.48 [a]	44.8 [a]	121.76 [a]	89.00 [a]	40.09 [a]	32.78a	171.07 [a]	86.41 [a]	86.84 [c]
Chow-tests		8.204 [a]	5.530 [a]	10.838 [a]	3.23 [b]	1.893	8.232 [a]	0.220	1.441	15.138 [a]	4.858 [a]	2.464 [a]

[a] $p < .01$ [b] $p < .05$ c $p < .10$

acteristics of industries and job functions make them different?

In terms of industrial sectors, Government is the only sector older and younger ITP alike make

virtually the same wage (the difference is 102 per cent). This may not be that surprising because government agencies are under the watchful eyes of Congress and the public and are more vulnerable to bad publicity if age discrimination was present. Among the sectors (Finance, IT and Medical) where age discrimination is found, age discrimination is the least severe in IT with wage ratio of 94 per cent, compared to 87 per cent for both Finance and Medical. This indicates that older ITP may be better off staying in the IT industry rather than leaving it. In Manufacturing, Transportation and Public Utilities, and Wholesale/ Retail, age discrimination is not confirmed. If we regard them as more traditional sectors, our results suggest that age discrimination is minimal when compared to the newer and more dynamic sectors such as IT, Medical, and Finance. In the newer and more dynamic sectors, it may be that there is a more prevailing perception that older ITP are not as suitable and productive as their younger counterparts.

Similarly, in terms of job functions, age discrimination is not confirmed in relatively traditional job categories such as QA Tester, Networking and Strategist/Architect. The greatest salary differences appear in the Web and MIS Manager categories, with older-younger salary ratios of 87 per cent and 89 per cent, respectively. Interestingly, for QA Tester and Strategist/Architect, the education premium is larger for older ITP than younger ones (0.065 vs. 0.041 and 0.036 vs. 0.031, respectively). In sharp contrast, the education coefficient is insignificant for older networking ITP. This may be attributed to the fact many older ITP may have earned certification on networking rather than going through formal university education.

It is also interesting that the coefficients of technical experiences and its squares for MIS Managers and Project Manager, who are 40 years old or older, are not significant while the corresponding coefficients for the younger counterparts are all very significant. This seems to suggest that once an older IT professional reaches a middle management position, the effects of additional technical experience on salary are negligible. In addition, the coefficients of the experience squared are not significant for Strategist/Architect and Top Management who are 40 or older. This indicates that there is no potential earning ceiling for older ITP who reach top management position. In terms of the experience premium, it is no surprise that younger ITP benefit more from experience than older ones except for Support Personnel in which the experience coefficients are 0.057 and 0.064 for younger and older ITP, respectively.

Data Concerns and Limitations

Some concerns can be raised by the representation of the survey respondents. First, the survey sample was not random since the respondents were self-selecting and voluntary; hence, non-representativeness and the self-report bias are a possibility. However, we feel that this potential bias would introduce little, if any, bias in our comparative analysis towards older or younger workers because it is likely that any such bias would be equally distributed for both subgroups of the sample. Second, the survey was on-line which may introduce a bias towards younger employees. While the number of younger respondents might be larger than expected, this potential bias in our comparative analysis towards older or younger workers would have little effect as we still have a large number of older respondents for reasonably accurate estimates of the coefficients in the different human capital models. Third, the survey was placed on an on-line placement company's web site, which may indicate that the survey respondents are more actively seeking new employment than typical ITP and likely tend to "sell themselves." Again, as this bias is expected to be similar between younger and older ITP, the salary differences in our analysis between younger and older ITP would not change significantly.

MANAGERIAL IMPLICATIONS AND CONCLUSIONS

This study provides an exploratory investigation for age discrimination with respect to IT wages. We employed the human capital model to assess the age treatment discrimination in salary benefits for ITP overall, by industry, and by job categories. Based on the results from this model, we have shown that age treatment discrimination exists in the overall IT workforce and provided a quantitative measurement of this treatment bias. In addition, age treatment discrimination is shown to not be uniformly observed across industries and job categories. Specifically, our results indicate that age treatment discrimination favors older employees over younger employees in some industries and it favors younger employees over older employees in other industries. Similarly, in the area of job categories, the results indicate that age treatment discrimination favors older employees over younger employees for some and favors younger employees over older employees for others.

Since age treatment discrimination is illegal in many countries, management needs to be very aware of this potential problem in all personnel matters. Similarly, in order to keep the loyalty of their older ITP, management needs to be aware of the different needs and priorities of their older workers. We offer four comments addressed to management on these issues.

First, in a tough economic environment, many companies feel that it is necessary to reduce their workforce. Older employees are often eliminated as an appropriate means of reducing employee costs (Gregory, 2001). Although they may not make the highest wages, older workers could be easily targeted simply as a result of being stereotyped. If management fails to treat older workers fairly in a workforce reduction, the older workers are probably more likely to take legal action against the company. Hence, it is essential that management treat all employees fairly during a workforce reduction. They should develop formal policies to address age discrimination.

Second, management should create an organizational culture that values older workers and recognizes the benefits of their employment. It is important to reevaluate the costs to retrain and renew ITP's skills due to the rapidly changing IT field in order to retain the loyalty of older ITP. Instead of attempting to find younger replacement for older ITP, management could provide training opportunities and use monetary incentives so older ITP renew their skill sets. These company supported training opportunities, however, may be limited or non-existent in a tough economic environment so it is essential that older ITP seriously consider all training opportunities (even those paid for by the worker) in order to maintain and enhance their employment value. In terms of future studies, it would be interesting to determine the human capital value of taking popular professional IT training courses and earning the different professional IT certifications. The finding of insignificant education premium for networking ITP in this study provides a good incentive and motivation for this extension.

Third, Jiang and Klein argue that as employees grow older, life interests and priorities may shift from work to other life activities (Jiang and Klein, 2002). In order to retain the loyalty of older ITP, management needs to pay attention to the changing work attitudes of older ITP and provide opportunities for balancing work related and non-work related responsibilities. On the other hand, in a tough economic environment where their company is reducing its workforce, older ITP need to be very aware that as their priorities shift away from work, their employment seniority and experience may not be sufficient to retain their jobs. Effective communication between management and older workers is critical -- "a continued dialogue among employers and others to proactively address the challenges of a maturing workforce will enhance the employment relationship, promote the development of more effective management

tools, and maximize the contributions of older persons both within and outside the workplace" (The Conference Board, 2003).

Fourth, the results of a study conducted by the National Science Foundation and the U.S. Census Bureau indicate a substantial decrease in the number of older computer programmers in the workforce. For example, 57 per cent of computer science graduates are working as programmers 6 years after completing their degree; at 15 years, that figure drops to 34 per cent; and at 20 years, it downs to 19 per cent (Matloff, 1998). These findings may indicate that age is a factor that affects programmer tenure. (An alternative explanation for this decrease is the natural career progression from technical to managerial positions.) In terms of future studies, it would be good to investigate the career path of computer programmers.

In terms of additional future studies, it would be interesting to link age with skills, organization sizes, and gender. For example, will different technical skills and people skills, such as communication and interpersonal skills, affect age treatment discrimination in the IT industry? Second, is age treatment discrimination uniformly practiced across different size organizations? The answers to these questions may help us understand age treatment discrimination better and provide relevant remedies.

Another area of future research is to investigate the extent of IT age discrimination in different parts of the world. For example, in a recent survey of ZhongGuanChun, the Silicon Valley in China, commissioned by the Beijing GuangXia Networking Technology, Inc., the average age of the ITP is 28.8. The average age for the middle management and top management is 31.46 and 36.56, respectively. Among computer hardware manufacturers and software developers, 65.83 per cent and 67.68 per cent, respectively, are between age 20 and 29, according to the online issue of the Epoch Times (2002). Does the survey information suggest access discrimination against older ITP exist in China or is it just because the population overall is relatively young? Another interesting question is whether age discrimination is more severe in the European Union than in the U.S.A. (possibly because of the later introduction of the legal protection of older people in the European Union). Preliminary evidence shows that while the employment rate of U.S.A. males age 55 to 64 stands at 65.6 per cent in 2000, it is only 38.5 per cent and 48.2 per cent for the two largest economies, France and Germany, in the EU, respectively (OECD, 2002). Do cultural and historical backgrounds play a role in discriminatory practices? Additional data collection and research are warranted to address age discrimination along the international dimension.

ACKNOWLEDGMENT

Jason Medick of DICE supplied the extensive survey data that is used in this study. In addition, Andrew Russell of DICE promptly answered numerous questions concerning the nature and structure of this data. He also shared with us his analysis of this data.

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APPENDIX: DATA TREATMENT

We have adopted the following rules (Table 6) in attempt to make the self-selected dataset clean. By doing so, some legitimate observations, in addition to the obviously outliers, may have been removed. But it is our belief that it is better to stay on the safe side.

Table 6.

Items	*Exclusion Rules*	*Rational*
Age	Age 1 (18 under), 7 (60-64) and 8 (65 and over)	Lack of representation
Education	Education 1 and Education 10	Education 1 is default value and 10 is Other, which is unknown to us.
Job Title	35: Non-IT: Executive/ Corporate 36: Non-IT: Financial 37: Non-IT: Manufacturing / Operations	Our interest is limited to ITP.
Hours per Week	Category 1 (< 20 hours/week)	This is the default value and if not carefully enough respondents would have unintentionally selected it.
Country	Non-U.S.A countries	Our Intention is to focus on U.S.A.
Age * Exp	(Age 18-24) AND (Experience of 11 years or more)	It is unlikely for young people to acquire this many years of experience
Exp * Yearly Salary	(Technical experience is less than 1 year) AND (Yearly salary is greater than $100K) (Technical experience is 1-2 years) AND (Yearly salary is greater than or equal to $125K)	Unlikely

Chapter 22
An Empirical Investigation of Stress Factors in Information Technology Professionals

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ABSTRACT

This study explores whether organizations can employ job design strategies to relieve organizational stress for information technology (IT) professionals. The effect of flexible work schedule, employee support and training, and telecommuting as potential coping resources to relieve stress were studied. Perceived workload, role ambiguity, work facilitation, and decision latitude were drawn from previous studies as potential stressors of IT professionals. Perceived stress was measured by two commonly used measures: work exhaustion and depressed mood. The results suggest that removing role ambiguity and improving work-facilitation ease work-related stress. Allowing employees to have flexible work schedules was also found to ease their perceptions of workload. Employee support and training strategies were found to influence decision latitude and role ambiguity. Telecommuting did not have any effect on the stressors. Results also indicate that the association between work exhaustion and depressed mood was stronger for males than females.

INTRODUCTION

Although the current favorable conditions in the labor market has somewhat mitigated the past acute shortage of IT professionals, recruiting and retaining qualified IT workforce continues to be an important endeavor for many organizations (Ang & Slaughter, 2004). The ability to retain valuable technical staff has been recognized as a critical factor for an organization in attaining its strategic goals (Agarwal & Ferrat, 1999; Agarwal & Ferratt, 2000; Ang & Slaughter, 2004; Moore, 2000). This study is based on the premise that by improving the work environment of IT professionals, organizations will be able to recruit and retain qualified personnel leading to improved organizational performance. For purposes, "IT professionals" is an umbrella term used to include a variety of employees who work within an IT department of a company including information systems developers, technical professionals, managers, and support personnel. The current study draws from well-established organizational stress research and proposes verification of an individual stress model in the IT context to prescribe organizational strategies to reduce stress. It attempts to first identify the stressors that appear to be most relevant in the IT context and then explores the usefulness of potential coping resources.

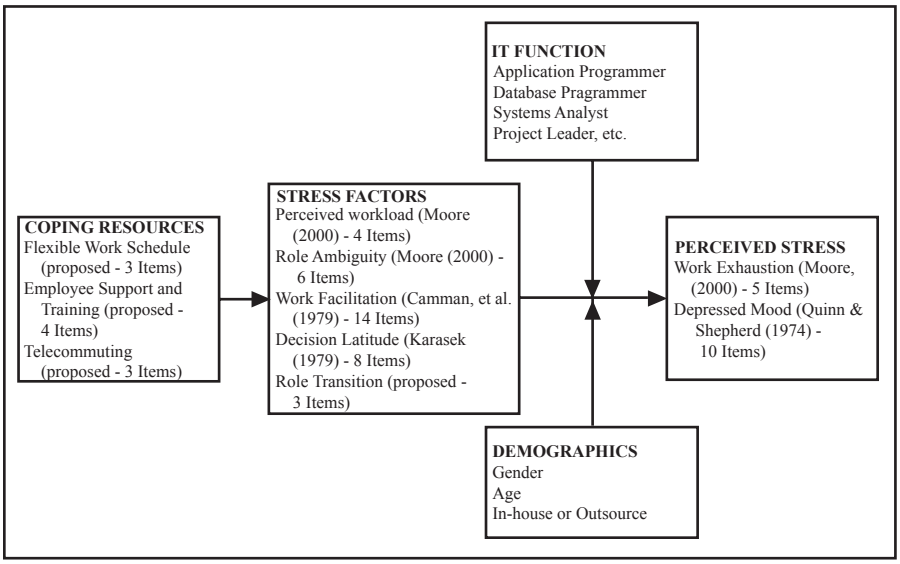
THEORETICAL FOUNDATIONS

Factors that cause job-related stress in general and specifically in the context of IT professionals, have been studied previously (Ivancevich, Napier, & Wetherbe, 1983; Moore, 2000; Weiss, 1983; Sethi, King, & Quick, 2004). Two contrasting theoretical frameworks guide organizational stress research. The demand-control model of occupational stress asserts that a combination of high job demands and low job decision latitude will lead to negative physical-health outcome (Karasek & Theorell, 1990). In a contrasting approach, the effort-reward imbalance model emphasizes the reward rather than the control structure of work (Siegrist, 1996). Self-regulation theory, in addition to the contrasting approaches mentioned above, emphasizes the processes of striving for personal success as a basis for understanding human behavior, functioning, and well-being (Maes & Gebhardt, 2000).

While there are rich multi-theoretic perspectives of organizational stress, some recent researchers feel that in spite of strong connections between dimensions of the work place, stress, and job satisfaction, there is no generally accepted theory of stress to enhance the conceptual understanding of these relationships (Fairbrother & Warn, 2003). Sullivan and Bhagat (1992) agree that there is considerable disagreement on basic theoretical and methodological issues of organizational stress research. There is also some recognition that a general model of stress is unhelpful in identifying the predictors of stress in specific job contexts, and consequently there is a move to formulate job-specific models in order to understand the relationships better. As an example, Sparks and Cooper (1999) recommend identifying salient workplace dimensions rather than a broad-brush approach when seeking workplace associations with stress. The current study adopts this recommendation and proposes a research model that includes potential coping resources such as allowing flexible working hours, employee support and training, and telecommuting that are particularly relevant to the IT context. The study does not seek to explore mental distress or physical illness that may result from stress.

The proposed model theorizes demographic factors including personal characteristics such as gender (Vermeulen & Cameron, 2000), age, and whether the IT professional is a direct or contract employee as well as the IT functional orientation of the employees as moderators of the perceived stress. A major goal of the current study is to prescribe organizational strategies to relieve stress in the context of IT professionals. Thus, it differs

Figure 1. Research model showing the stress-factors perceived-stress relationship



from studies (as for example in Moore, 2000) that attempt to study related effects of stress such as turnover intentions or attempt to develop a comprehensive model of organizational stress.

Constructs Elaboration

There are five components of the conceptual model: stress factors that are treated as independent variables, perceived stress as defined by work exhaustion and depressed mood which are treated as outcome measures, coping resources that are possible organizational strategies to ease stress, IT functions, and finally, demographic factors that may be moderators on the relationship between stressors and perceived stress.

Stress Factors

There is anecdotal evidence to affirm that IT professionals are generally overworked (McGee, Khirallah, & Lodge, 2000). Cost savings and other economic incentives for IT projects tend to be high resulting in organizations having unrealistic expectations. Shorter development times are generally the norm in such high expectation environments. Sweeny and Summers (2002) found that accounting professionals who have to work too long and too hard at too many tasks felt more stressed. Moore (2000) examined the effect of work exhaustion in technology professionals and found that IT professionals experiencing higher levels of exhaustion reported higher turnover intentions.

IT professionals associated with projects that are less structured and ill defined may have some anxiety about their ability to meet expectations by their superiors. Such projects typically increase the role ambiguity and role conflict for project participants. Role ambiguity and role conflict have been shown to affect occupational stress and career satisfaction (Igbaria, Parasuraman, & Badawy, 1994). Role ambiguity and role conflicts due to poor project planning and management practices are not uncommon. Role variables on IS personnel work has been studied previously and role ambiguity was found to be the most dysfunctional variable in IS personnel (Baroudi, 1985). A

recent study found that perceived organizational support has strong effects on role ambiguity and role conflict as well as job satisfaction and intent to remain (Stamper & Johlke, 2003). A scale from Moore (2000) for measuring role ambiguity is used. Decision latitude is generally defined as the worker's potential control over his or her tasks and his or her conduct during working hours. Karasek (1979) studied 950 workers and found that low decision latitude accompanied by heavy job demands resulted in mental strain. All eight items from his classic decision latitude scale were adapted for the current study.

Work-family integration affords people a greater opportunity to achieve personal goals and lead more satisfying lives and consequently reduce work-related stress (Friedman & Greenhaus, 2000). A study based on boundaries and micro-role transitions found that highly integrated work environments (as in the case of IT professionals carrying pagers and thus expected to be available during those times) decreases the magnitude of change between work and other life contexts, but increases blurring (Ashforth, Kreiner, & Fugate, 2000). This increased blurring renders boundary creation and maintenance more difficult thus contributing to increased stress. The proposed research model incorporates this "role-transition" as a possible stressor.

Work facilitation for IT professionals is an important dimension of an IT environment. IT projects thrive on coordination among project participants. The model uses a production-orientation (the extent to which the supervisors are productivity-oriented), the extent of perceived control of work by the IT professionals, ability of the supervisors in setting reasonable goals and solving problems, as well as the work-facilitation strategies employed by the supervisors. Seashore, Lawler, Mirvis, and Camman (1982) have described the work facilitation factors used in this study. In their Michigan Organizational Assessment questionnaire, Camman, Fichman, Jenkins, and Klesh (1979) include 30 items to measure 10 aspects of leadership as perceived by subordinates. Measures used in the current study are adopted from those 30 items.

Perceived Stress

The outcome variables of the model are work-exhaustion and depressed mood. Since "psychological distress" is outside the scope of this study, outcome measures such as life dissatisfaction and low self-esteem (as in Beehr, 1981) as well as physical health outcomes (as in Karasek & Theorell, 1990) are not included in the conceptualization. It is believed that such general psychometric measures are largely influenced by factors other than occupational stressors and hence the conceptualization is confined to two direct measures of stress: work exhaustion and depressed mood. Work-exhaustion is often defined as job burnout, and Moore (2000) has justified the use of a revised conceptualization of burnout based on Schaufeli, Lieter, and Kalimo (1995). The scale used in Moore (2000) is particularly suited for use with information technology professionals as the original scale was validated in the context of IT professionals. Depressed mood has also been used as a descriptor of work-related stress (Higgins, Duxbury, & Johnson, 2000; Heinisch & Jex, 1997). The work-exhaustion scale (Moore, 2000) and the depressed-mood-at-work scale (Quinn & Shepard, 1974) were included in the survey instrument.

Potential Coping Resources

The current study focuses on those stress relievers that are within the direct control of the organization and consequently can form the core of organizational strategies to be employed as stress relievers. Research on cognitive patterns and stress, although very valuable, is anchored at an individual level (Chilton, Hardgrave, & Armstrong, 2005). However, the goal of this study is to suggest ways for organizations to understand

and manage stress at an organizational level and thereby help them manage IT professionals through better personnel strategies. This goal draws theoretical support from studies that prescribe human resource practices of organizations as part of a symptom-directed approach to stress intervention (Teo & Waters, 2002).

Allowing employees to work a flexible schedule is likely to relieve stress arising out of work-life balancing issues. Many organizations now recognize the importance of flexible work hours and other life balancing programs as a means of recruiting and retaining IT professionals. Eaton (2003) found a relationship between workplace flexibility policies and organizational commitment and self-reported productivity. Telecommuting can provide relief from stress arising out of the commute to work. A primary objective of organizational virtual work programs is the reduction of employees' work-non-work conflict and job stress (Raghuram & Wiesenfeld, 2004). It should be noted that the current study does not examine the impact of telecommuting on productivity. It only investigates the effect of telecommuting on reducing stress factors.

Professional development activities, such as job training sponsored by an organization, can be used as a stress reliever as this increases the employees' self-worth. The need to keep up with technology is possibly greater for IT professionals compared to other types of employees within an organization, and consequently such professional development activities may play a greater role as stress relievers among IT professionals. Bartlett (2002) found that perceived access to training, social support for training, motivation to learn, and perceived benefits of training are positively related to organizational commitment. Allowing a flexible work schedule, providing employee support and training, and offering a telecommuting option are the three stress relievers incorporated in the model.

Information Technology Functions

Different levels of IT professionals perform drastically different functions. The nature of work at these different levels is also considerably different (Hsu, Chen, Jiang, & Klein, 2003). As an example, a systems analyst might be expected to interact with other people within and outside the organization whereas there may not be such expectations for an application programmer (Wynekoop & Walz, 1998). The present study includes the job function of an IT professional as a moderator in the stressors and perceived stress relationship.

Demographics

The role of gender and age differences in information technology perceptions is generally recognized (Morris, Venkatesh, & Ackerman, 2005) and specifically differences between genders on perceived job demands, job control, and job stress levels has been established (Piltch, Walsh, Mangione, & Jennings, 1994). A recent study has found that temporary and permanent workers differ in job insecurity and health-related outcomes of work environment (Silla, Gracia, & Peiró, 2005). Wynekoop and Walz (1998) found different personality characteristics among different IT functions, such as programmers, analysts, and managers. This research model conceptualizes the effect of potential coping resources, and generally recognized stressors on perceived stress among IT professionals and includes the aforementioned demographic variables. IT professionals employed directly by an organization are likely to have greater organizational commitment than professionals temporarily involved in a project as an outsourced contract worker. This differentiation often results in certain interesting dynamics in the IT work environment. Sometimes there are meetings and social events within an organization that are directed only toward regular employees. Although organizations differ in the way they look at contract employees, attitudinal differences on

the part of IT organizations may be a source of stress for the contract worker. Regular employees may also experience a certain level of stress in these environments as they may feel less secure about their jobs in an environment of increasing contract employees. Thus, the status of an individual as an in-house employee or an outsourced contractor is another demographic characteristic included in the study.

Recent studies have also supported the inclusion of gender as a moderating variable for determining organizational stress among IT Professionals. Women have reported lower job satisfaction on a dimension that captures job stress, and this effect was more pronounced where the organization expected its IT employees to innovate (Gallivan, 2004).

METHODOLOGY

A pilot study to establish the general readability as well as the reliability and validity of the survey instrument was first conducted. The respondents for the pilot test were 59 entry-level workers. Factor analysis was later used to test how well the individual items converged on the intended scales and also to examine whether these items loaded on scales other than the ones intended. Items revealing inconsistencies were removed and scales were purified. These guidelines were suggested by Churchill (1979) and Hatcher (1994). A purified questionnaire was then used in the main study.

A sequence of four steps was used for analyses of the data collected for the main study. First, a confirmatory factor analysis was conducted to establish convergent and discriminant validity for all constructs. This resulted in elimination of certain items and the role transition construct. Second, a preliminary structural equation model was tested for only direct influences of the conceptual model. Third, coping resources were added as antecedent variables. Finally, the demographic factors were incorporated in the structural equation model by conducting a multi-group analysis to study their moderating effects on the main model.

Issues of Validity

The face validity of the newly developed constructs of role-transition, flexible work schedule, employee support and training, and telecommuting were verified with the pilot study participants. Churchill (1979) suggested calculation of coefficient alpha, the elimination of items, and the subsequent recalculation of alpha as a series of steps to be followed in developing scales for measuring a construct. These iterative steps were followed to arrive at the final list of items, as reported in the Appendix.

An initial analysis of the data supported a claim of reliability and validity for seven of the constructs, while the remaining four constructs needed further purifications. "Depressed mood at work" appeared to be multidimensional. The analysis identified three sub-dimensions of this construct, suggesting more complexity in this factor than was identified in the model. Also, the moderator variables of "employee support and training" and "telecommuting" were somewhat colluding, but this could be the result of higher percentages of same results due to the lack of both measures in organizations. Factor analysis was then used to establish the convergent and discriminant validity of the constructs.

Data Collection

Surveys were distributed to 27 organizations in the Midwest United States through contact persons. These contact persons enabled distribution of the questionnaire only to appropriate respondents in information technology. Since smaller organizations have IT employees who may be performing cross-disciplinary functions, it was decided to use only those organizations that had at least one hundred employees. Although a form of convenience sampling was used, it helped ensure that participating organizations were representative of the target population of

organizations with at least 100 IT employees. Profiles of the organizations surveyed as reported in Table 1 indicate a representation from seven industries with at least two firms in each industry and verifies that there was no industry specificity in the surveyed organizations.

There were 179 responses representing seven different industries. An additional 34 of the respondents did not identify their industry affiliation. Table 2 summarizes the demographic characteristics of survey respondents. The gender ratio, national origin, the composition of in-house and contract employees, and professional title of respondents verify that the data collected did not over represent any one group.

Further Purification of Constructs

The data were used to test the reliability and validity of the scales once again, before verifying the model using structural equation modeling. Each group of constructs was factor analyzed using principal component analysis with varimax rotation. This resulted in elimination of certain items and removal of the role transition construct from further analyses.

Five of the items RA6, WF07, WE1, WE2, and DM06 loaded on more than one factor. DM10 did not load on any particular factor. DM01, DM02, DM03, and DM08 loaded on the factor WE (work exhaustion) as well. Since multiple constructs to

Table 1. Number of responses collected from different industries

Industry	Number of Firms	Responses
Energy, Utilities	2	27
Retailing	2	16
Education	3	47
Information technology services	3	7
Industrial	3	30
Financial services	2	30
Insurance	2	22
Not identified	10	34
Total	**27**	**213**

Table 2. Demographic profile of respondents

(n = 213)	Mean	Median	Range
Age	35.29	34	18-56
IT experience	9.9 yrs.	6.0 yrs.	Less than a year—32 yrs.
Current employment	6.5 yrs.	4.0 yrs.	Less than a year—31 yrs.
Gender	Male: 145 (68.1%), Female: 68 (31.9%)		
National origin	U.S.: 176 (82.6 %), India: 30 (14.1 %), Other: 7 (3.3%)		
Title	Application programmer: 52 (24.4%), System analyst/engineer: 48 (22.5%), IS/IT director/manager: 26 (12.2%), Web designer/developer: 16 (7.5%), Other: 69 (32.3%)		
Internal/External employee	Internal: 175 (82.2%), External: 36(16.9%)		

Table 3. Reliability of measures

		Initial		After Purification	
Construct	**Source**	**# of Items**	**Coefficient Alpha**	**# of Items**	**Coefficient Alpha**
Perceived Workload (PW)	Moore (2000)	4	.82	4	.82
Role Ambiguity (RA)	Moore (2000)	6	.82	4	.79
Decision Latitude (DL)	Karasek (1979)	8	.78	5	.83
Work Facilitation—Subordinate Relations (WF)	Camman et al. (1979)	14	.92	9	.92
Role-Transition (RT)	(Newly Developed)	3	.59	2	.62
Work Exhaustion (WE)	Moore (2000)	5	.87	3	.82
Depressed Mood At Work (DM)	Quinn and Shepherd (1974)	10	.88	4	.78
Flexible Work Schedule (FW)	(Newly Developed)	3	.86	3	.86
Employee Support and Training (ST)	(Newly Developed)	4	.76	4	.76
Telecommuting (TC)	(Newly Developed)	3	.82	3	.82

Table 4. Correlation matrix for scales

	Mean	S.D.	WE	DM	PW	RA	WF	DL	RT	FX	SP	TC
WE	4.654	1.264	1									
DM	3.158	1.122	**0.437****	1								
PW	3.070	1.226	**0.578****	**0.235****	1							
RA	2.622	0.964	**0.230****	**0.348****	**0.191****	1						
WF	4.399	1.497	**0.263****	**0.239****	**0.277****	**0.561****	1					
DL	3.471	1.324	0.126	**0.182****	0.102	**0.420****	**0.361****	1				
RT	2.598	1.169	**0.223****	0.049	**0.259****	-0.019	0.016	-0.110	1			
FX	4.589	1.509	-0.089	**-0.214****	**-0.201****	-0.126	**-0.157****	**-0.252****	-0.078	1		
SP	4.721	1.431	**-0.202****	**-0.184****	**-0.144***	**-0.293****	**-0.474****	**-0.438****	0.074	**0.217****	1	
TC	3.131	1.437	-0.079	-0.122	-0.185	**-0.186****	**-0.185****	**-0.185****	-0.047	**0.429****	**0.281****	1

** *Correlation is significant at the 0.01 level (2-tailed)*

* *Correlation is significant at the 0.05 level (2-tailed)*

conceptualize perceived stress are being used, and for the first time work exhaustion (WE) along with depressed mood (DM) is being used, testing for items loading into both factors and eliminating them from further analyses were felt as an important step in purifying the data. These items were dropped from further analyses, and reliabilities of scales were recalculated (see Table 3). Although in some of the scales, the alpha was lowered, the alpha is .70 or higher in most of the cases. Table 3 summarizes the internal consistency measures (Cronbach's alpha) using the new data. Table 4 summarizes the means, standard deviations, and scales correlations among constructs used in this analysis.

ANALYSIS AND RESULTS

As discussed earlier, a sequence of four steps was used for data analyses: first, a confirmatory factor analysis was conducted; second, a preliminary structural equation model was tested for only direct influences of stressors on perceived stress; third, coping resources were added as antecedent variables; and fourth, the demographic factors and IT function were incorporated in the structural equation model to study their moderating effects. Structural equation modeling was considered a preferred approach for the analyses compared to other available alternatives. The results from the Monte Carlo study conducted by Goodhue, Lewis, and Thompson (2006) suggest that PLS does not have special abilities with respect to statistical power at small sample sizes. Marcoulides and Saunders (2006) also warn against the misuse of PLS in analyses with small sample sizes. Although the sample size of 213 is considered adequate, in conducting multi-group analysis where the sample is split into two groups, the sample size for each group will be closer to the levels that are not recommended by both these studies.

Influence of Stressors on Perceived Stress

The results of the measure development yielded the following main research model. In this model, the main effects of stress factors on perceived stress were first tested; therefore, the moderating effects of demographics and the effects of coping resources are not depicted. All the variables were entered in LISREL (for Windows version 8.51) at the same time.

The first model assumed all the stress factors affect both work exhaustion and depressed mood at work directly. It also assumed that WE affects DM. All possible gamma coefficients were estimated for this fully interrelated model, including all possible paths among four independent and two dependent factors.

The results show that both perceived workload and work facilitation strategies affect work exhaustion, and role ambiguity influences depressed mood. There is a significant relationship between work exhaustion and depressed mood. There was no significant relationship between decision latitude and perceived stress found.

Organizational Strategies

The ability to detect and accurately estimate interaction effects is especially critical to IS research (Chin, Marcolin, & Newstead, 1996). Mediating variables are those that account for the relationships between a predictor variable and the dependent variable (James & Brett, 1984). During the next stage of data analysis it was explored whether three specific organizational strategies—flexible work schedule, employee support and training, and telecommuting—can be employed to mitigate the effect of the predictor variables on perceived stress. The original model was then revised to include the three organizational strategies as antecedents of the predictor variables. As can be seen from the correlations in Table 4, it is expected that such stress relievers have negative effects to stress factors. Structural equation modeling using LISREL 8.51 was again used to test the paths of such effects. All the gamma coefficients were estimated, while only selected beta coefficients were estimated based on the significant Phi (covariance between Ksi variables) from Figure 2. This means that only the significant paths among stress factors were retained for further testing in this model. The directions of beta coefficients (e.g., work facilitation to perceived workload, not the other way around) were determined by using only conceptually justified influences. The results are shown in Figure 3.

Telecommuting did not result in a significant correlation to any of the stressors while flexible work schedule and employee support and training had significant correlations as seen in Figure 3.

Figure 2. Structural equation model (latent variables) showing path coefficients

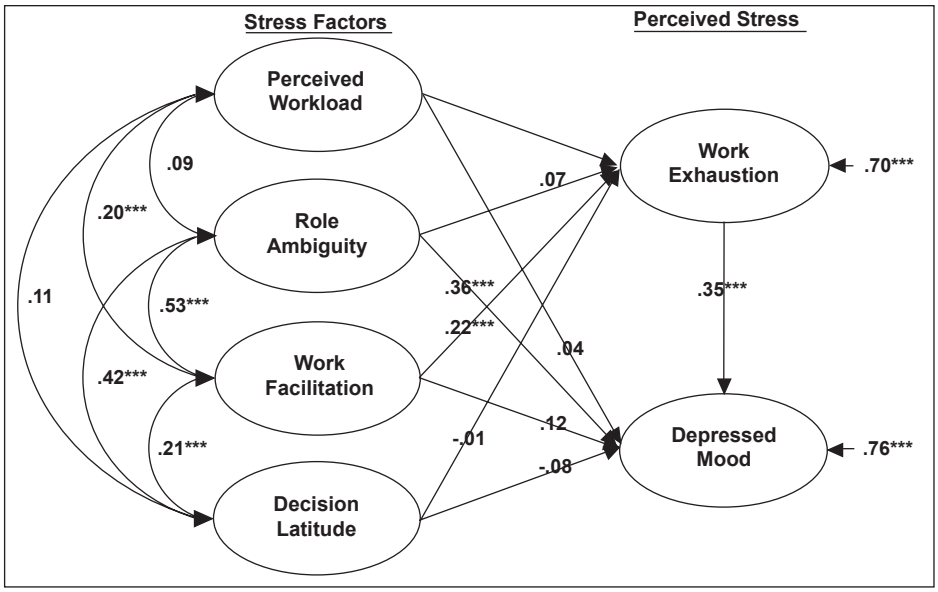
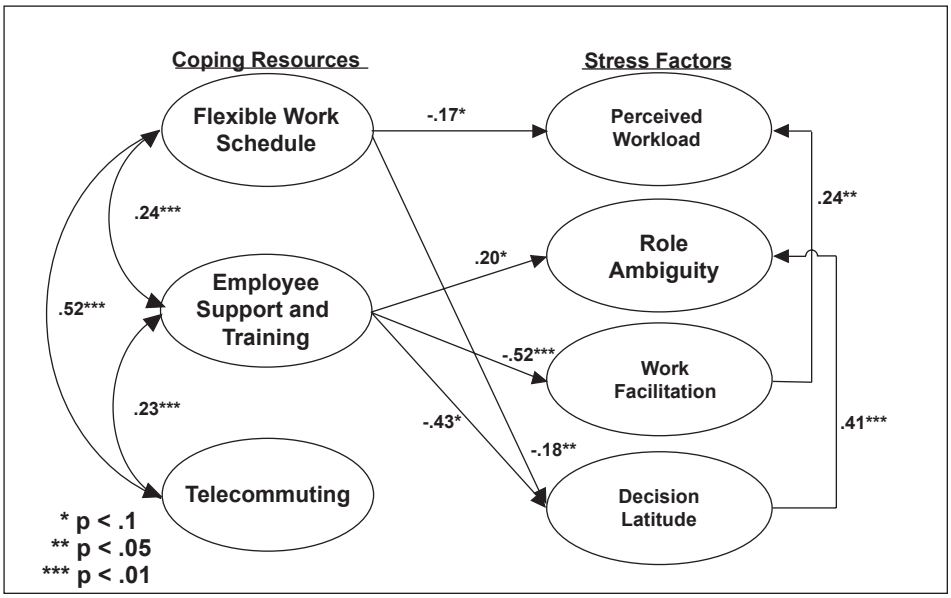


Figure 3. Structural equation model with organizational strategies as antecedents



Moderating Effects

The fourth and final step of data analysis was testing for the moderating effects. Gender, age, whether the professionals were "in-house" or "outsourced," and the functional areas of the IT professionals were the four demographic factors tested as moderators of the relationship between

stress factors and perceived stress. Following the nested goodness-of-fit strategy to test for moderating effects suggested by Jaccard and Wan (1996), a three-step sequence was employed for analyzing the moderating effect of each of the demographic factors. In the first step, subjects were divided into two groups based on the demographic factor being studied and LISREL 8.51 was used to generate the goodness-of-fit in terms of Chi-square when each group's path coefficients were estimated freely. In the second step, one of the coefficients (gamma or beta) was restricted to impose an across-group constraint to reflect the interaction effect. In the third step, the difference in model fit (Chi-square) for the restricted solution and free solution was calculated based on the size of this difference (with *df* =1), and a conclusion about the interaction effect was made.

Moderating Effects of Gender

The results of the path coefficient analysis (step 1) showed that if the subjects were divided into two groups, the path from WF to WE became not significant in the female group. Other coefficients were significant in both groups. Equality constraints model analysis (step 2 and 3) revealed that when only path from PW to WE or when only path from WE to DM was fixed, the changes in Chi-square were significant ($p<.10$). The results are shown in Table 5. This led to the conclusion that gender moderated the relationship between perceived workload and work exhaustion, in a sense that both groups had a strong correlation between the two constructs, but the degree of association was stronger in the female group than in the male group. Also, gender moderated the relationship between work exhaustion and depressed mood; the association was stronger in the male group than in the female group.

Moderating Effects of Age

The subjects were divided into two age groups using median (34 years old) split. In the analysis of free estimation (step 1), the path from WF to WE became not significant in both less-than-34-years-old (young) group and 34-years-old-or-more (old) group. In the old group, the path from RA to DM was also not significant. Other coefficients were significant in both groups. These changes might be a direct effect of the decline in the sample size (210 to 103 or 104). Equality constraints model analysis (step 2 and 3) found no significant differences in Chi-squares, as shown in Table 6.

Moderating Effects of In-House/ Outsourced Employee Characteristic

The sample was divided into two groups, in-house employees and outsourced contractors. Outsourced contractors were defined as those

Table 5. The results of the moderating effects of gender

Path	Male (n=145)		Female (n=68)		Restricted model		χ^2	$\Delta\chi^2$	p-value
	coefficient	t-value	coefficient	t-value	coefficient	t-value			
PW → WE	0.27	**3.91**	0.49	**4.46**	0.33	**5.64**	11.54	2.85	**0.0914**
WF → WE	0.25	**3.04**	0.22	**1.90**	0.24	**3.58**	8.71	0.04	0.8415
RA → DM	0.19	**1.94**	0.34	**2.42**	0.24	**3.00**	9.52	0.83	0.3622
WE → DM	0.43	**4.87**	0.16	**1.27**	0.33	**4.59**	11.86	3.17	**0.0750**

Note: Restricted model's χ^2 is 15.39 (df=12), and completely free model's χ^2 is 8.69 (df=8). The difference in χ^2 is 6.70 (df=4), (p=0.1526).

Table 6. The results of the moderating effects of age (median (34 yrs old) split)

Path	Less than 34 yrs. old (n=103)		34 yrs. old or more (n=104)		Restricted model		χ^2	$\Delta\chi^2$	p-value
	coefficient	t-value	coefficient	t-value	coefficient	t-value			
PW → WE	0.29	**3.67**	0.44	**4.66**	0.35	**5.84**	10.76	1.05	0.3055
WF → WE	0.20	**1.84**	0.24	**2.58**	0.22	**3.16**	9.75	0.06	0.3065
RA → DM	0.35	**2.87**	0.22	**1.94**	0.28	**3.39**	10.21	0.52	0.4708
WE → DM	0.44	**4.27**	0.22	**2.26**	0.33	**4.62**	12.01	2.32	0.1277

Note: Restricted model's χ^2 is 14.45 (df=12), and completely free model's χ^2 is 9.69 (df=8). The difference in χ^2 is 4.76 (df=4), (p=0.3128).

who were working in companies different from ones they were employed by (such as a consulting company). There were 175 in-house employees and 36 outsourced contractors. The analysis yielded statistically significant moderating effects. When the coefficients were estimated freely (step 1), only the in-house group had a significant association in the path from PW to WE. The outsourced group did not. On the other hand, the path from WF to WE was not significant in the in-house group but was significant in the outsourced group. The results of the equality constraints model analysis (step 2 and 3) showed that the Chi-square differences for the paths of PW-WE and WF-WE were significant ($p < .1$). The results are shown in Table 7. This leads to the conclusion that whether the respondents are in-house employees or outsourcers has moderating effects on the relationships between perceived workload and work exhaustion (in-house group has stronger association, $p<.1$) and work facilitation and work exhaustion (outsourced group has stronger association, $p<.1$).

Moderating Effects of IT Functions

The subjects were divided into two groups (step 1); one group consisted of application programmers, Web designers/developers, and database programmers/data administrators (programmers) and the other included project leaders, supervisors, IS/IT directors/managers, and CIO's/vice presidents (supervisory/managerial). The path from WF to WE was rendered insignificant in

Table 7. The results of the moderating effects of in-house/outsourced employee characteristic

Path	In-house (n=175)		Contractor (n=36)		Restricted model		χ^2	$\Delta\chi^2$	p-value
	coefficient	t-value	coefficient	t-value	coefficient	t-value			
PW → WE	0.39	**6.17**	0.07	0.51	0.34	**5.80**	7.80	3.83	**0.0503**
WF → WE	0.18	**2.40**	0.54	**2.99**	0.23	**3.32**	7.10	3.13	**0.0769**
RA → DM	0.23	**2.58**	0.46	**2.29**	0.27	**3.27**	4.86	0.89	0.3455
WE → DM	0.32	**4.08**	0.39	**2.17**	0.33	**4.59**	4.08	0.11	0.7401

Note: Restricted model's χ^2 is 11.17 (df=12), and completely free model's χ^2 is 3.97 (df=8). The difference in χ^2 is 7.20 (df=4), (p=0.1257).

the supervisory/managerial group. This might be a direct effect of the decline in the sample size (210 to 94). Equality constraints model analysis (step 2 and 3) found no significant differences in Chi-squares indicating no moderating effects of IT functions, as shown in Table 8.

DISCUSSION

Job stress was conceptualized in two important dimensions of work exhaustion and depressed mood, and presented a model of occupational stress as applied to information technology professionals. The current study incorporated potential coping resources the can be modified by organizations with appropriate human resource strategies. Flexible work schedule, employee support and training, and telecommuting were analyzed as potential coping resources that may relieve stress. This analysis provided important results that are practically relevant. A significant relationship between flexible work schedule and perceived workload was found. This means that allowing IT professionals to follow a flexible work schedule can alleviate work exhaustion through its influence on perceived workload. The results of the current study confirm prior findings from other work environments. Almer and Steven (2002) reported that accountants with **flexible work schedules** report higher job satisfaction and lower turnover intentions than those on a standard **work** arrangement. This finding is consistent with their result of lack of support for flexible work schedule's influence on role ambiguity, but contradicts their finding of lack of support for the relationship between flexible work schedule and role overload. A significant negative relationship between flexible work schedule and perceived work load was found, indicating that the greater the flexibility of the work schedule, the lesser will be the perceived work load.

Recent studies have established that there is a general correlation between employee development strategies and positive organizational outcomes such as organizational commitment (Tansky & Cohen, 2002). The current study explores this relationship in greater detail. The results show that employee support and training strategies influence perceived workload through work facilitation. Support and training strategies had significant influence on decision latitude and role ambiguity. A possible explanation of this influence is that proper training may help employees to make job decisions confidently and thus diminish role ambiguity.

A rather curious finding is the lack of support for telecommuting as an organizational strategy for reducing stress. It can probably be explained by theories of boundary spanning (Ashforth et al., 2000), which propose that lack of clear boundaries between work place and home can actually

Table 8. The results of the moderating effects of IT functions

Path	Programmers (n=76)		Management (n=94)		Restricted model		χ^2	$\Delta\chi^2$	p-value
	coefficient	t-value	coefficient	t-value	coefficient	t-value			
PW → WE	0.28	**2.75**	0.39	**4.73**	0.35	**5.39**	17.33	0.70	0.4028
WF → WE	0.31	**2.92**	0.16	1.46	0.23	**3.09**	17.61	0.98	0.3222
RA → DM	0.28	**2.43**	0.12	0.84	0.22	**2.38**	17.25	0.62	0.4310
WE → DM	0.25	**2.16**	0.37	**3.53**	0.31	**4.01**	17.13	0.50	0.4795

Note: Restricted model's χ^2 is 18.85 (df=12), and completely free model's χ^2 is 16.63 (df=8). The difference in χ^2 is 2.22 (df=4), (p=0.6954).

increase stress. This is in contradiction to the somewhat popular belief that allowing employees to telecommute is a good work facilitation strategy (Venkatesh & Vitalari, 1992). The finding highlights that it may be critical that the organization not simply accept the value or importance of telecommuting but actively promote and support it (Khalifa & Davision, 2000). Simple acceptance as was evaluated in the study may not be enough to raise telecommuting to the level of a potential stress reliever.

The current study explores whether IT job functions and the nature of employment (whether employees are in-house or outsourced) as moderating variables. These have not been studied in previous research on job stress. Although it was found that there are no moderating effects of IT functions, this may be due to the combining different job functions into two groups: managerial and technical, necessitated by poor sample sizes in each job functions if held separately. Specific studies relating to job functions are necessary to explore the effect of job functions in greater detail.

Both perceived workload (PE) and work facilitation (WF) are found to have significant influence on work exhaustion (WE), while role ambiguity (RA) has a significant influence on depressed mood both directly as well as through work exhaustion. Although inconsistent with Moore's (2000) findings, Beauchamp, Bray, Eys, and Carron (2002) and Tu, Ragunathan, and Ragunathan (2001) have found significant relationship between role ambiguity and other stress-related outcomes. Role ambiguity in an IT context can result from not following proven strategies, such as specifying user requirements clearly to software development professionals. The study suggests that organizational strategies to reduce role ambiguity are likely to have a positive impact on relieving stress among IT professionals.

Results of the current study also support the significance of gender as a moderator of stress. Although the relationship between perceived workload and exhaustion was significant in both male and female IT professionals, the association was stronger in the case of female workers. On the other hand, the association between work exhaustion and depressed mood is stronger in the male group.

Another demographic characteristic, whether the IT professional is an in-house or outsourced employee, was found to have a moderating effect on multiple relationships: between perceived workload and work exhaustion, between work facilitation and work exhaustion, and between role ambiguity and depressed mood. In-house employees have a strong association between perceived workload and work exhaustion but outsourced workers do not, indicating the amount of work is not a stress factor for outsourced employees. It confirms previous results that suggest temporary employment is negatively associated with absenteeism and stress as compared with full time permanent employment (Benavidesa, Benacha, Diez-Rouxb, & Romana, 2000). This can also be explained by the fact that outsourced employees may perceive a constant inflow of work as an assurance of continued employment and possible extensions of their contract.

The results show that age is not a significant moderator of stress. The multi-group analysis used a median split of 34 for the two groups that were analyzed. Although this is a commonly employed split strategy, 34 may not have been the cut-off level at which age has moderating effects on stress and the reported lack of support for age as a moderator has to be viewed with caution.

Dropping of the role transition construct due to poor convergent and discriminant validity is not expected to undermine the conclusions as this was just one of the stressors explored in the research model. Previous studies support that blurring boundaries between work and family is linked to increased distress and lower family satisfaction (Ashforth et al., 2000; Noelle, 2005). This prior support suggests a possible direction of future research to better understand the influence

of role transition. Future research can focus on developing validated measures for this construct. Although it was set out to study role transition, the measures created did not pass the convergent and discriminant validity tests.

A limitation of the study is its restriction of samples to only organizations with more than 100 IT professionals. The findings may not be applicable to smaller groups of IT professionals. There may be other contextual factors specific to small companies. This study did not include those contextual variables. Future research can focus on the factors that are specific to smaller organizations. Another limitation of the study is that it treats IT professionals as just two groups rather than distinguishing among different types of IT professionals. Although data was collected on different types of IT professionals, it was not possible to incorporate that in the structural equation model due to sample-size constraints. Further research is needed to study the effects of stressors with different types of IT professionals.

It has been suggested that there are gender differences in the way IT professional adapt to telecommuting (Beasley, Lomo-David, & Seubert, 2001). Another limitation of the study is that it was not set out to study such complex interactions and it is believed that it should be left to specific studies exploring the demographic characteristics in greater depth. It was articulated that the context of work environment would deeply affect the job stress phenomena. This study specifically focused on IT professionals as subjects. However, the model did not incorporate other contextual variables related to the personal lives of IT professionals. Although cognitive and personal factors such as political skill, trust, and justice are important factors in determining work-related stress, these are not as directly affected by organizational policies and practices such as flexible work schedule, employee support and training, or telecommuting. They were not incorporated in the study to focus more clearly on strategies for managing stress by adopting policies and practices at an organizational level.

CONCLUSION

The history of organizational stress research is long and its findings are extremely wide in their scope. While the current study draws relevant constructs from previous research, its goal was to provide guidelines for organizational strategies for relieving stress by proposing a model that is appropriate for IT professionals' context. It did not seek to formulate and verify an overall model for organizational stress incorporating all potential stressors. In addition, the current study focused on just the stressors and potential coping resources rather than including outcomes of organizational stress such as turnover intentions. This narrower focus enabled the specification of guidelines that are practically relevant and useful. The results show that project managers can employ work facilitation strategies such as solving work-related problems or allowing employees to develop their professional skills can help in relieving work exhaustion.

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APPENDIX: SCALES USED IN DATA COLLECTION

Part 1: Perceived Workload

		Strongly Disagree	Disagree	Slightly disagree	Neutral	Slightly Agree	Agree	Strongly Agree
PW1	I feel that the number of requests, problems, or complaints I deal with is more than should be expected.							
PW2	I feel that the amount of work interferes with how well it is done.							

		Once a year or less	A few times a year	About once a month	2 or 3 times a month	About once a week	Almost daily	daily
PW3	I feel busy or rushed.							
PW4	I feel pressured.							

Part 2: Role Ambiguity

		Strongly Disagree	Disagree	Slightly disagree	Neutral	Slightly Agree	Agree	Strongly Agree
RA1	I feel certain about how much authority I have. ®							
RA2	Clear, planned goals and objectives exist for my job. ®							
RA3	I know that I have divided my time properly. ®							
RA4	I know what my responsibilities are. ®							
RA5	I know exactly what is expected of me. ®							
RA6	Explanation is clear of what has to be done. ®							

Part 3: Work Facilitation-Subordinate

		Strongly Disagree	Disagree	Slightly disagree	Neutral	Slightly Agree	Agree	Strongly Agree
WF1	My supervisor in this project demands that people give their best effort. ®							
WF2	My supervisor in this project insists that subordinate work hard. ®							
WF3	My supervisor in this project demands that we do high-quality work. ®							
WF4	My supervisor keeps me informed of the work done by other participants in the project. ®							
WF5	My supervisor plans out work in advance. ®							
WF6	My supervisor handles the administrative parts of the projects extremely well. ®							
WF7	My supervisor makes sure that subordinates have clear goals to achieve. ®							
WF8	My supervisor makes subordinates know what has to be done. ®							
WF9	My supervisor ensures that the infrastructure (such as PCs, software) is available for the project in time. ®							
WF10	My supervisor helps me solve work-related problems. ®							

WF11	My supervisor helps subordinates develop their skills. ®
WF12	My supervisor has the respect of subordinates. ®
WF13	My supervisor is always fair with the subordinates. ®
WF14	My supervisor tends to play favorites.

Part4: Decision Latitude

		Strongly Disagree	Disagree	Slightly disagree	Neutral	Slightly Agree	Agree	Strongly Agree
DL1	My job generally requires high skill level in my area. ®	1	2	3	4	5	6	7
DL2	I am required to learn new things as part of my job. ®							
DL3	My job entails doing the same thing everyday.							
DL4	I have opportunities to be creative in doing my job. ®							
DL5	I have freedom in how I do my job. ®							
DL6	My job allows making a variety of decisions. ®							
DL7	I have relevant information for making decisions relating to my job. ®							
DL8	I have control over the outcome relating to the job I am responsible for. ®							

Part 5: Role-Transition Issues

		Never	a few times a year	once a month or less	a few times a month	once a week rather often	few times a week nearly all the time	daily
RT1	I get called at home or paged outside of work hours to answer work-related questions.							
RT2	I think about work-related issues at home.							
RT3	When I get home, I forget about work and concentrate on my family and non-work issues. ®							

Part 6: Work Exhaustion

		Never	a few times a year	once a month or less	a few times a month	once a week rather often	few times a week nearly all the time	daily
WE1	I feel emotionally drained from my work.							
WE2	I feel used up at the end of the workday.							
WE3	I feel fatigued when I get up in the morning and have to face another day on the job.							
WE4	I feel burned out from my work.							
WE5	Working all day is really a strain for me.							

Part 7: Depressed Mood at Work

		Never	a few times a year	once a month or less	a few times a month	once a week rather often	few times a week nearly all the time	daily
DM1	I feel down-hearted and blue.							
DM2	I get tired for no reason.							
DM3	I find myself restless and can't keep still.							
DM4	My mind is as clear as it used to be. ®							
DM5	I find it easy to do the things I used to do. ®							
DM6	I feel hopeful about the future. ®							
DM7	I find it easy to make decisions. ®							
DM8	I am more irri-table than usual.							

DM9	I still enjoy the things I used to. ®	
DM10	I feel I am useful and needed. ®	

Part 8: Organizational Strategy to Cope With Stress

Flexible Work Schedule

		Strongly Disagree	Disagree	Slightly disagree	Neutral	Slightly Agree	Agree	Strongly Agree
FW1	My organization actively promotes flexible work schedule programs.							
FW2	My organization provides support for flexible work schedule.							
FW3	I have all productivity tools available in my regular environment available in my flexible work schedule environments as well.							

Training and Support

		Never						Often
ST1	My organization recognizes IT technical skills I acquire on my own.							
ST2	My organization allows time off to attend IT seminars/training.							
ST3	My organization provides financial support to my IT training.							
ST4	My organization conducts in-house IT seminars/ training.							

Telecommuting

		Strongly Disagree	Disagree	Slightly disagree	Neutral	Slightly Agree	Agree	Strongly Agree
TC1	My organization actively promotes telecommuting programs.							
TC2	My organization provides training and support to telecommuting.							
TC3	I have all productivity tools available in my regular environment available in my telecommuting environments as well.							

This work was previously published in Information Resources Management Journal, Vol. 21, Issue 2, edited by M. Khosrow-Pour, pp. 1-28, copyright 2008 by IGI Publishing (an imprint of IGI Global).

Chapter 23
Information Technology Portfolio Management:
Literature Review, Framework, and Research Issues

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ABSTRACT

There is significant interest in managing IT resources as a portfolio of assets. The concept of IT portfolio management (ITPM) is relatively new, compared to portfolio management in the context of finance, new product development (NPD), and research and development (R&D). This article compares ITPM with other types of portfolio management, and develops an improved understanding of IT assets and their characteristics. It presents a process-oriented framework for identifying critical ITPM decision stages. The proposed framework can be used by managers as well as researchers.

INTRODUCTION

IT investments constitute a major portion of organizations' capital budgets in many organizations (Jeffery & Leliveld, 2004). However, some authors question the business value of IT (Carr, 2003), and the actual contribution of IT to organizational performance is the subject of debate (Kohli & Devaraj, 2003). IT managers are constantly under pressure to justify their IT investments and demonstrate the business value of IT. For most companies, selecting a project that would fit the corporate strategy—and therefore maximize the business value—is a challenging process (Jeffery & Leliveld, 2004). In addition, the high failure rate of IT projects in many organizations is a cause for

concern. A study by Standish Group showed that only 28% of IT projects succeed in 2004, compared to 34% a year earlier (Hayes, 2004).

Hence, there has been significant interest in effective management of information technology investments (Cimral & Lawler, 2002; Datz, 2003; Jeffery & Leliveld, 2004; Reyck, Grushka-Cockayne, Lockett, Calderini, Moura, & Sloper, 2005). Organizations recognize that they have portfolios of IT assets. Each component of the portfolio (e.g., applications, projects, and infrastructure) serves a different purpose and needs to be managed differently, while recognizing the interdependencies between these components. Several organizations have undertaken IT portfolio management (ITPM) projects (Datz, 2003; Jeffery & Leliveld, 2004; Weill & Vitale, 1999). An increasing number of vendors and consultants offering ITPM products , services, and books are beginning to appear (Fitzpatrick, 2005; Maizlish & Handler, 2005). However, organizations have different maturity levels when it comes to implementing ITPM (Jeffery & Leliveld, 2004). There are significant additional benefits that can be obtained from better understanding and implementation of ITPM (Weill & Aral, 2006).

From a research perspective, there are several studies that address portfolio management. These research studies span diverse fields, such as new product development (NPD) (Cooper, Edgett, & Kleinschmidt, 1997, 1999), research and development (R&D) (Dickinson, Thornton, & Graves, 2001), financial portfolio management (FPM) (Reilly & Brown, 2002), and IT (Jeffery & Leliveld, 2004). However, an analysis of similarities and differences between ITPM and other types of portfolio management is lacking in the literature. Such an analysis would help researchers, as well as managers, apply ideas from other types of portfolio management that can be used for ITPM.

From an MIS perspective, there are very few studies directly related to ITPM (Jeffery & Leliveld, 2004; Weill & Aral, 2006; Weill & Vitale, 1999). ITPM as a concept remains underdeveloped. However, there are several streams of research that seem to be relevant to ITPM. These include business values of IT (Devaraj & Kohli, 2003), IT project management (Wallace & Keil, 2004; Wallace, Keil, & Rai, 2004), IT adoption and use (Jasperson, Carter, & Zmud, 2005; Venkatesh, Morris, Davis, & Davis, 2003), IT success (DeLone & McLean, 2003), strategic use of IT (Bhatt & Grover, 2005; Piccoli & Ives, 2005), strategic IS planning (Grover & Segars, 2005), business process change (Kettinger & Grover, 1995), and others. Hence, there is a need to better understand how these streams of research are related to ITPM, and further develop ITPM from a research perspective.

This article views an organization's IT portfolio as comprising a set of assets: IT infrastructure assets (the hardware and software that support IT applications such as servers, workstations, database software, and network infrastructure), application assets, project assets, and IT-related human resource assets. This view of the IT portfolio mirrors the way many organizations manage their IT assets, and is discussed in Section 3. Application, infrastructure, and project components of the IT portfolio are the focus of this article, since managing the human component of the IT portfolio is an important topic in its own right.

Jeffrey and Leliveld (2004, p. 41) define ITPM as "managing IT as a portfolio of assets, similar to a financial portfolio, and striving to improve the performance of a portfolio by balancing risk and return." This article views ITPM as *a continuous process to manage IT project, application, and infrastructure assets and their interdependencies, in order to maximize portfolio benefits, minimize risk and cost, and ensure alignment with organizational strategy over the long run*. This view of ITPM specifically recognizes different types of IT assets, the continuous process nature of ITPM, and identifies major dimensions (alignment, benefits, costs, risks, and interdependencies) that need to be considered in managing IT as a portfolio of assets. It is important to note that

some researchers would consider alignment to be a type of benefit. However, identifying it as a separate characteristic of an IT portfolio helps to maintain focus on the important goal of aligning IT with organizational strategy.

This article focuses on the following questions:

i. What are the core concepts of (other types of) portfolio management?
ii. How do these core concepts apply to IT portfolio management?
iii. How do relevant, major, existing MIS research streams relate to ITPM?
iv. How do existing IT management practices relate to ITPM?

This article presents a cumulative body of relevant knowledge to aid future development of ITPM by addressing the above questions. It develops a conceptual framework for better understanding and managing ITPM by (a) reviewing and synthesizing related literature, (b) identifying core concepts of portfolio management that cut across financial, NPD, and R&D contexts (e.g., assets, alignment, costs, benefits, risks, interdependencies), and (c) developing these core concepts in an MIS context by integrating relevant ideas from MIS literature with ideas from other types of portfolio management. The proposed framework systematically identifies major steps and decisions in ITPM. It could be of use to researchers who are interested in further development of ITPM, as well as practitioners. Areas for future research are identified by using this framework to compare existing research in MIS with research in other types of portfolio management. The use of this framework in an organizational context is illustrated using an example.

The article is organized as follows: Section 2 provides a review of related literature from the fields of NPD, R&D, financial portfolio management, and MIS. Core concepts of portfolio management in the context of IT are discussed in Section 3. A framework for understanding ITPM decisions and processes is described in Section 4. An example to illustrate the use of the ITPM decisions and processes framework is provided in Section 5. Managerial Issues are discussed in Section 6. Conclusions are presented in Section 7.

LITERATURE REVIEW

Portfolio management is typically associated with financial assets. Besides finance, other fields such as NPD, R&D, and MIS have used portfolio management concepts. This section summarizes relevant research.

Financial Portfolio Management

Portfolio management in finance (Reilly & Brown, 2002) deals with managing a variety of asset classes (such as stocks, bonds, cash) in order to maximize return for some specified period of time, while attempting to minimize risk. Each asset class can contain a variety of subclasses. These include different types of stocks (small-cap, mid-cap, international, and so on) and different types of bonds (domestic, international, junk, short-term, long-term, inflation adjusted, and so on). These asset classes vary in terms of their risk-return characteristics, as well as liquidity. Risk-return characteristics of portfolios are different from those of individual stocks, and are influenced by the degree of correlation between assets in the portfolio.

Financial asset holders typically select a portfolio of assets in relation to their strategic goals (e.g., retirement) and risk tolerance. They periodically trade (buy and sell) assets in order to rebalance (ensure that their portfolio continues to be aligned with their strategic goals). Trading costs influence the frequency with which they trade. Relatively liquid assets can be traded at relatively lower trading costs. The value of each

financial asset is typically determined by markets. Costs of these assets include actual asset costs, trading fees, and asset management fees (for managing or maintaining a portfolio). Effective management of a financial portfolio comprising different types of assets often results in higher expected returns with an acceptable level of risk over a defined time horizon.

Major research issues in financial portfolio management include portfolio selection, risk-return characteristics of different types of financial assets, portfolio management, the impact of trading costs, and a variety of other issues (Elton, Gruber, Brown, & Goetzmann, 2002).

NPD Portfolio Management

NPD portfolio components are projects which result in products that can be marketed. The literature suggests numerous reasons for the popularity of NPD portfolio management practices (Cooper & Edget, 2003). These include scarcity of organizational resources, project failure rate, and the misalignment between projects and strategic decisions. Many companies find portfolio management useful in providing them with systematic ways to decide which projects to undertake and to help them track the deployment of existing resources (Cooper & Edget, 2003; Cooper et al., 1999). Cooper, Edgett, and Kleinschmidt (2004a, 2004b, 2004c) examined best portfolio management practices in several organizations, and found that portfolio management approaches are related to higher organizational NPD performance. More specifically, research shows that high-performing companies (in terms of revenue percentage from new products or other metrics) have a higher proportion of innovative projects in their portfolio than low-performing companies. This emphasizes the importance of the mix of projects in a portfolio. The NPD literature contains several streams of research on portfolio management.

One stream extends financial portfolio management and microeconomic theory to incorporate the unique characteristics of new product investments. Leong and Lim (1991) developed a multiperiod portfolio evaluation framework based on financial portfolio concepts. Relevant financial concepts include the correlation between projects (divisions), interproject relations (synergies), changes in risk and returns over time, and the effect of buy/sell decisions on portfolio performance. Devinney and Stewart (1988) extended the microeconomic theory of the firm, while paying close attention to "interdependency between demand and supply in new product line investment." The model presented in their article takes into consideration the interaction between cost, revenue, and profitability of products.

Another stream of research presents different project selection methodologies a firm can use to maximize its return and achieve the right balance of projects. In a series of articles, Cooper et al. (1997, 1999) evaluate different project selection and value maximizing practices employed by a set of firms. Examples of these practices are: NPV, productivity index, and scoring models. Cooper et al. (1999) recommended the use of hybrid portfolio evaluation methods. Financial methods such as NPV, IRR, or productivity index, strategic methods, scoring models, and finally, bubble diagrams where projects can be viewed in terms of risk and reward can be used to evaluate projects (Cooper et al., 1999). Other combinations of methods can be used when evaluating and selecting new projects. For example, managers can use a mix of analytic hierarchy process (AHP) and simulations to help them decide on the best project, based on predefined criteria (Ayag, 2005). Loch and Kavadias (2002) developed a dynamic model of selecting new product lines using a marginal analysis approach. The dynamic model takes into consideration multiple factors, such as interaction of multiple product lines (substitution or complementary), resource synergies, uncertainties, potential size of the market segment, and management risk aversion.

R&D Portfolio Management

The use of portfolio management in R&D resource allocation began in the 1980s (Dickinson et al., 2001). Because high-technology firms cannot afford to develop one product at a time, they face the challenge of concurrently managing multiple R&D projects using shared resources (Verma & Sinha, 2002). The goal of R&D portfolio management is to optimize the resource allocation among projects in a way that balances risk, benefits, and align projects with corporate strategies (Dickinson et al., 2001). Components in a R&D portfolio are projects. Project selection and evaluation represent a major managerial effort in R&D portfolio management. Researchers have identified different types of interdependencies among R&D projects, such as resource interdependencies, outcome interdependencies, and benefit interdependencies (Chien, 2002; Verma & Sinha, 2002). Because of the existence of the various interdependencies, the combination of individually optimal projects does not necessarily constitute the optimal portfolio (Chien, 2002). Therefore, portfolio management techniques which take into consideration all possible projects at the same time are required.

There are a wide range of R&D portfolio management techniques with varying metrics and evaluation/selection methods. The metrics used to evaluate and select a project include quantitative (e.g., ROI) and qualitative (e.g., alignment with company strategy) measures. Different portfolio management techniques have been developed to evaluate different metrics. Mathematical and scoring/weighing models could be used when quantitative measures are available (Dickinson et al., 2001; Ringuest et al., 2000; Stummer et al., 2003). Matrix and charting could be used to explore qualitative measures (MacMillan & McGrath, 2002; Mikkola, 2001). Professional judgment is often considered another valuable decision source in R&D portfolio management (Dickinson et al., 2001).

Portfolio Management in IT

The information systems literature contains few studies on portfolio management. Similar to research in other disciplines, researchers have examined methods and models to measure the risk and value of different portfolio components, such as project portfolio risk (McFarlan, 1981) and application health (Weill & Vitale, 1999). Others have presented models to select projects in an IT portfolio (Bardhan & Sougstad, 2004). Although several methods to measure the value and risk of IT portfolio components exist, many companies are missing the full benefits of ITPM. According to a survey of 1,000 CIOs—while 89% of them were aware of ITPM, and 65% believed that it yields significant business value—only 17% think they have realized ITPM's full value (Jeffery & Leliveld, 2004). Hence, companies could benefit from an improved understanding of ITPM. ITPM is not a new topic in information systems research; it goes back to the early 1970s, when researchers started studying information systems within the context of the entire organization (Lucas, 1973). Recently, there has been a renewed interest in the topic, given the challenges facing companies in managing their IT assets more effectively. This renewed interest is due, in part, to articles such as Carr (2003) that have questioned the business value of IT.

Jeffrey and Leliveld (2004) discussed best practices in ITPM based on a survey and interviews. They also suggest that an IT portfolio maturity model be used to characterize different levels of ITPM implementation in organizations. Weill and Broadbent (1998) classified IT assets into transactional assets, informational assets, strategic assets, and infrastructure assets. They illustrate that the relative proportion of these four types of assets in an organization is related to corporate strategy. For example, an organization whose business strategy is based on cost leadership would emphasize transactional assets, while an organization whose business strategy is

based on agility would emphasize strategic assets. Weill and Aral (2006) emphasized that the effective implementation of ITPM in organizations is related to developing IT savvy, which is a set of five interrelated characteristics. Of these five characteristics, three (use of IT for internal and external communication, internet use, and digital transactions) are practices related to IT use, and two (companywide IT skills, and management involvement) are competencies.

UNDERSTANDING ITPM

Financial, NPD, R&D and IT Portfolios: Similarities and Differences

Financial, NPD, R&D, and IT portfolio management have similarities and differences. This section analyzes these similarities and differences using the following characteristics or dimensions of portfolios: portfolio components, strategic alignment, benefits, costs, risks, and interdependencies. An analysis of each dimension includes a discussion of MIS research related to that dimension. This analysis forms the basis for the ITPM decision framework presented in the following section.

Portfolio Components or Assets

Asset types in the case of FPM include different types of stocks and bonds. Portfolio assets are typically projects in the case of NPD and R&D portfolios. However, there could be different types of projects, just as there are different types of stocks or bonds.

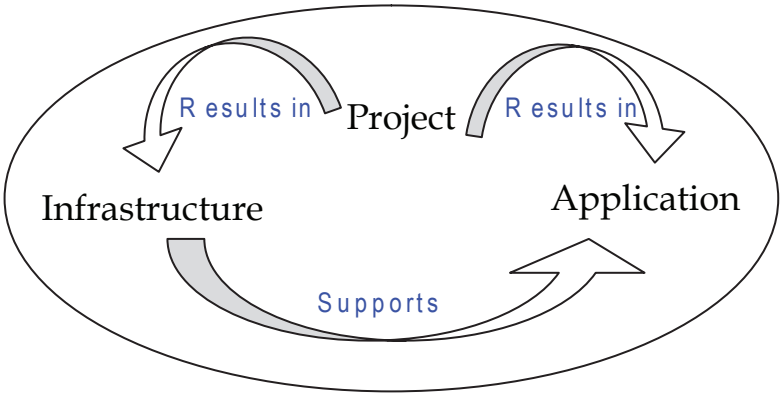
Asset classes in IT portfolios include projects, applications, and infrastructure.[1] Figure 1 illustrates the interrelationship between these three asset classes. Completed IT projects could result in applications (e.g., purchasing systems), or infrastructure components (e.g., messaging system). Infrastructure components, in turn, support applications.

Of these, IT projects have been extensively researched, particularly from project success and risk management perspectives (Schmidt, Lyytinen, Keil, & Cule, 2001; Wallace & Keil, 2004; Wallace et al., 2004) and continue to be an active area of research. MIS research on IT applications spans several streams. These include IT adoption and use (Venkatesh et al., 2003), IT success (DeLone & McLean, 2003), and deriving business value from applications (Devraj & Kohli, 2003). Research on IT infrastructure is relatively new and includes streams, such as infrastructure value (Kumar, 2004), infrastructure flexibility (Byrd & Turner, 2000; Duncan, 1995), and infrastructure management (Weill & Broadbent, 1998; Weill & Vitale, 2002).

A benefit of viewing IT assets as projects, applications, and infrastructure is that it mirrors the way IT assets are managed in organizations. In the case of financial portfolios, groups of specialists manage different types of assets. For example, fixed income (bond) securities are managed by different groups of managers than equities or stocks. Similarly, in the case of IT portfolios, projects are typically managed by project and application development groups, applications are managed by support groups and infrastructure is managed by architects and network or infrastructure support groups. While there is some job rotation between these groups, the organization structure in many IT organizations distinguishes between project or development groups, application support groups, and infrastructure support groups. Different (sometimes overlapping) skills are required for project management, application development, application support, and infrastructure support. Table 1 summarizes some key characteristics of IT assets. These characteristics are discussed in the following sections.

IT portfolios include architecture, project, and infrastructure subportfolios (Figure 2).

Figure 1. Relationship among projects, infrastructure, and applications

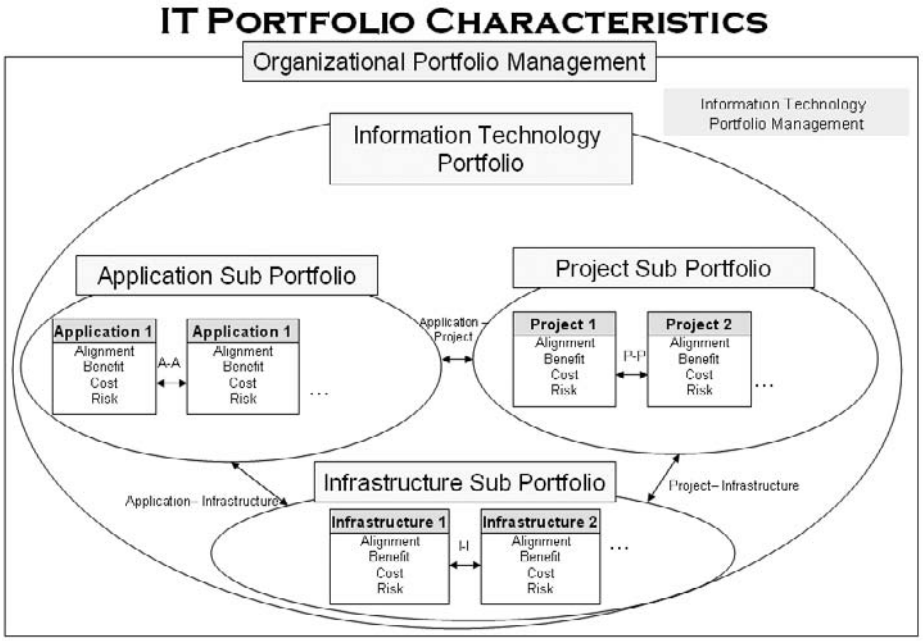


Researchers studying project subportfolios have examined issues such as interdependent project evaluation (Bardhan & Sougstad, 2004) and use of different project management approaches depending on the type of project (Applegate, Austin, & McFarlan, 2006). Reyck et al. (2005) classified implementations of IT project portfolio management (PPM) into three stages and provide empirical evidence (based on European data) that adoption of PPM is highly correlated with improved project performance. Weill and Vitale (1999) proposed a framework for analyzing an organization's application subportfolio based on benefits and risk, and managing applications based on this analysis.

Table 1. Key characteristics of projects, applications, and infrastructure assets

Characteristic	Projects	Applications	Infrastructure
Management responsibility	Project managers	Support groups	Architecture groups
Benefits	Determined as part of a business case.	Determined after implementation	Determined after implementation. Relatively difficult to determine
Costs (major)	Programming costs +purchased hardware/software costs + project management costs	Application license costs + support (labor) costs+ allocated infrastructure costs	License costs+ support (labor) costs
Risks (major)	Risks of the project not being completed on time, within budget, or not producing desired benefits	Risks of application downtime and risk of the application not being adopted or used as planned	Risks of infrastructure downtime
Alignment with Strategy	Projects are related to strategic goals (e.g. reduce cost)	Applications support strategic business processes	Strategic architecture decisions impact organizational performance

Figure 2. Information technology portfolio characteristics: components, alignment, benefit, cost, risk, and interdependency



Characteristics of IT Portfolio Components

Strategic Alignment

All four types of portfolio management (FPM, NPD, R&D, ITPM) emphasize the need to align the portfolio with long-term goals or organizational strategies. However, there are some differences. NPD and R&D typically focus on a few products or processes. However, IT is significantly more pervasive than NPD and R&D, because IT investments can impact a variety of processes or products. Some of the tools that have been proposed to align NPD and R&D projects with corporate strategy, such as scoring models, can also be used to align IT investments with corporate strategy. However, strategic planning for IT is likely to be more complex, and involves a variety of diverse stakeholders. MIS research (Grover & Segars, 2005; Newkirk & Lederer, 2006) which emphasizes the importance of a strategic information systems planning (SISP). This stream of research has identified important process elements of SISP (Newkirk & Lederer, 2006) and the results of successful SISP (Grover & Segars, 2005; Segars & Grover, 1998). SISP success measures include increased alignment, improved analysis and understanding of an organization's relationship with IT, improved cooperation, and important capabilities such as the ability to identify key problem areas and flexibility to adapt to unanticipated changes. Research on financial portfolios, NPD, R&D, and IT portfolios has recognized the need to have a mix of different types of assets in the portfolios. The mix of different types of assets would be related to an organization's strategic goals. As discussed earlier, Weill and Broadbent (1998) classify an organization's IT investments into transactional, informational, and strategic, and illustrate that the relative proportions of these types of assets

is related to an organization's strategy. Weill and Aral (2006) provide empirical evidence of organizational benefits from planned portfolios that include strategic investments in IT.

Benefits

Organizations would typically like measurable financial benefits that could be quantified by means of financial calculations from all investments. Financial assets often have market-determined values. Hence, determining the value of a portfolio is relatively easy. However, the value of a portfolio could vary considerably over time. The value of NPD and R&D portfolios is typically based on projected project benefits. NPD project benefits are typically based on market research and projected sales. R&D project benefits could be more difficult to estimate, compared to NPD project benefits, depending on the type of R&D project, since R&D projects often require follow-up commercialization projects. Scoring models or financial measures are typically used to determine value, though several more sophisticated methods, often based on financial management, have been proposed, as have hybrid approaches.

There is an extensive body of literature on the business value of IT (Devaraj & Kohli, 2003). Several methods for evaluating the business value of IT projects have been proposed. These include traditional financial measures (Ross & Beath, 2002) and more sophisticated methods, based on financial asset evaluation (Benaroch & Kauffman, 1999; Santos, 1991). However, it is well-recognized that it is often difficult to quantify the benefits of IT projects, particularly if they relate to infrastructure (Kumar, 2004). It has also been recognized that different types of evaluation methods may be appropriate, depending on the type of IT project (Ross & Beath, 2002). Hence, quantifying the benefits of a portfolio of IT projects can be difficult.

A growing body of literature exists on post hoc analysis of the business value of IT applications (Kohli & Devaraj, 2003). These studies typically use econometric analyses to determine the value of IT applications. The MIS literature recognizes that the business value of IT investments is influenced to a large extent by complementary investments in training and business processes (Weill & Aral, 2006), and by the extent to which an application is used in the organization (Devaraj & Kohli, 2003).

The business value of IT infrastructure investments can be particularly difficult to determine. Their value is determined in part by the value of applications they support, and in part by their ability to enhance organizational flexibility. Hence, relatively sophisticated techniques, such as those described in Kumar (2004), may be required.

In the case of financial portfolio management, it is possible to assign a value to a portfolio of assets. The total value of NPD and R&D portfolios can be estimated if projected financial metrics are available for projects. However, the total value (benefit) of an IT portfolio (comprised of projects, applications, and infrastructure) can be difficult to articulate, since different methods of determining the values of these portfolio components may be used at the portfolio component or subportfolio level, and determination of value is imprecise. Scoring models and approximate financial valuation using appropriate approximate techniques for projects, infrastructure, and applications is possible. Additional research on approaches to specifying portfolio value is required.

Costs

Costs of financial assets can be classified into acquisition costs, holding costs, and disposal costs. Acquisition costs include the purchase price and trading commissions. Holding costs typically include different types of asset management fees, which could vary depending on the type of asset (e.g., savings accounts, brokerage accounts). Disposal costs typically refer to commissions. In the case of NPD and R&D portfolios, organiza-

tions are concerned primarily with project costs. Completed projects result in products or services, which are then commercialized.

In the case of IT portfolios, IT projects are similar to NPD and R&D projects, in terms of project cost being the primary concern. The application and infrastructure assets that result from projects are similar to financial assets, in that one can think in terms of acquisition costs (could be the same as project costs), holding (or support) costs, and disposal costs for these assets.

Support (or holding, or management) costs for IT application and infrastructure assets have some important characteristics, which need to be emphasized. While support costs are typically a relatively small percentage of asset value in the case of financial assets, they can be a significant portion of total costs in the case of some application and infrastructure assets, and need to be carefully managed.

In the case of financial assets, organizations are not interested in tracking support costs for each individual asset. However, in the case of IT assets, organizations often incur significant infrastructure and support costs. Hence, they would like to assign these costs to different departments or user organizations. Chargeback or cost allocation systems are used for this purpose. Also, costs of one asset class (e.g., application or project) are related to those of another asset class (e.g., infrastructure), and hence, calculating total costs of an application or project might require some way of allocating or charging back cost of infrastructure assets to applications or projects. Chargeback of IT costs to users is a controversial topic, and user departments are not always satisfied with chargeback mechanisms and the behavior modifications that they induce (Drury, 2000). However, organizations continue to use chargeback systems (Quinlan, 2002), and with the growing trend towards IT being delivered as a service, it is likely that innovative methods of assigning shared costs of infrastructure to applications and users (Gerlach, Neuman, Moldauer, Argo, & Frisby, 2002; Hoffman, 2005) merit additional research (Thornton, 2005).

Risk

Risk is often viewed as the possibility of deviation from an expected outcome (Wallace et al., 2004). Financial, NPD, R&D, and IT portfolios differ in terms of the magnitude and relative importance of different types of risks. Risks have been extensively studied in the financial domain, and are typically classified into market or systematic risks, and private or unsystematic risks. Market risk factors are typically correlated with the risks to the overall financial market, and include major economic factors such consumer confidence, oil prices, and interest rates. Market risk can be hedged by holding a diversified portfolio of securities. Private risk, on the other hand, is specific to individual projects, and is the result of factors that are not correlated with market risk. These include technical risks, project management risks, and organizational risks.

NPD portfolios typically have a significantly higher market risk compared to R&D portfolios, which have a significantly higher private risk (often technical risk). Risk factors of IT portfolios are likely to be primarily private risks. Also, the definition of risk and relevant risk factors could vary for project, application, and infrastructure subportfolios.

Risk, in the context of IT projects, can be defined as the possibility of an unfavorable outcome in terms of time, cost, or functionality of the final project deliverable (Wallace & Keil, 2004). There is an extensive body of literature on identifying risk factors for IT projects (Schmidt et al., 2001), and managing risk in IT projects (Schmidt, Lyytinen, K., Keil, & Cule, 2002; Wallace et al., 2004; Wallace et al., 2004; Westerman, 2005; Westerman & Walpole, 2005).

This article defines risk in the context of IT applications as *the likelihood of the application not delivering the expected business benefits.*

Application risk factors include the risk of low adoption and use, and risk of application downtime. Risk of low rates of application adoption and use is often the result of behavioral factors and related to the MIS literature on IT adoption (Venkatesh et al., 2003) and IT success (DeLone & McLean, 2003). Risk of application downtime could be related to security risks (Arora, Hall, Pinto, Ramsey, & Telang, 2004; Rainer, Snyder, Carr, & Houston, 1991; Sun, Srivastava, & Mock, 2006). It is important to note that there is a need for research that focuses on IT application risk from an integrated perspective that includes all types of IT assets.

Infrastructure risk can be defined in a manner similar to application risk as *the likelihood of the infrastructure not delivering the desired business benefits*. However, the business benefits of infrastructures are more difficult to measure when compared to those of applications. Infrastructure risks include natural disasters, terrorist attacks, power failure, software bugs, etc (Arora et al., 2004; Rainer et al., 1991; Sun et al., 2006). Thus, while risk has been studied in some contexts (e.g., project risk), IT risk management is an underdeveloped area, and there is a need for additional research that examines risk management in IT from an integrated perspective, and examines the relationships between project, application, and infrastructure risks. There is a growing recognition that IT risk management may be a valuable organizational capability (Westerman, 2005; Westerman & Walpole, 2005). Other disciplines such as operations management recognize the fact that risk management in their discipline is underdeveloped and encourage additional research in this area (Seshadri & Subrahmanyam, 2005).

Interdependencies

In general, interdependencies refer to situations where characteristics (alignment, benefits, costs, risks) of a portfolio asset depend on characteristics of another asset. Interdependencies have a major impact on the value of an IT portfolio over time. Interdependencies between assets have been extensively researched in finance. Project interdependencies have also been studied in NPD, R&D, and IT research. The relationship between projects may be positive (complement), negative (substitute), or zero (neutral) (Chien, 2002; Devinney & Stewart, 1988). Chien (2002) identified four types of interrelationships among projects: outcome or technical, cost or resource-utilization, impact or benefit, and serial (present-value) interrelationships. Outcome interrelationships occur when a project outcome depends on the other projects outcomes. Cost interrelationships exist in a portfolio when the total cost of the portfolio cannot be represented as the sum of the costs of the individual projects. Benefit interrelationships among the projects in a portfolio make the payoffs of the projects not additive. Serial interrelationships arise when time is considered as a factor in selecting the projects in a portfolio. Santhanam and Krypakis (1996) discussed three types of interdependencies involving IT projects: resource, benefit, and technical. Resource dependencies involve shared resources such as hardware and software. Benefit interdependencies arise when projects are synergistic. Technical dependencies arise when completion of one project is dependant on completion of other projects, due to technical reasons.

The MIS literature differentiates between hard and soft dependencies (Bardhan & Sougstad, 2004). Hard dependencies exist when a capability developed for one project is required by one or more other projects. Soft dependencies are when a capability from one project supports or enhances capabilities of other projects. In general, however, the concept of interdependencies between different types of IT assets is underresearched in MIS, but extremely important if IT is to be managed as a portfolio of assets. Table 2 summarizes different types of interdependencies between IT assets. For example, Cell 1 in Table 2 indicates that new project proposals may depend on other

approved and in-progress projects for shared resources (e.g., a common server or storage area network). It may also be possible that a new project proposal depends on some other project for shared benefits (an e-commerce project might depend on the completion of an infrastructure upgrade project for enhanced benefits). Cell 7 indicates a different type of dependency. An existing infrastructure component (e.g., server) might depend on a proposed security project for risk reduction. Similarly, the infrastructure might depend on an in-progress server consolidation project for cost reduction.

These interdependencies are also shown in Figure 2. Shared resources could include hardware, software, or personnel. A detailed analysis of different types of dependencies and their impact on ITPM decisions is an interesting research area. Other disciplines such as R&D management have recognized the need to understand dependencies in greater detail, and contain qualitative (Verma & Sinha, 2002), as well as quantitative studies (Dickinson et al., 2001) that result in improved understanding of different types of dependencies.

This section has summarized key issues in understanding ITPM. A comparison of major ITPM issues with other types of portfolio management is provided in Table 3. This table provides a comparative overview of different type of portfolio management and references to appropriate pages for additional detail.

ITPM DECISIONS AND PROCESSES

Implementing ITPM in organizations involves several interrelated business processes, such as processes for business case development, IS planning, and project management. Many organizations are likely to have some of these processes in place. Hence, it is possible to think of organizations being at different levels of maturity, as far as ITPM is concerned (Jeffery & Leliveld, 2004). This section presents a framework for understanding the relationships between different decisions that are part of ITPM. This framework was derived from the literature review by means of the following process:

a. First, different types of decisions relating to individual assets were identified from the MIS literature (e.g., project selection decisions).
b. Second, decisions relating to portfolios of IT assets (e.g., managing groups of projects) were identified from the NPD, R&D, finance, and MIS research.

Table 2. Interdependencies between IT portfolio components

	(Other) Approved and In-Progress Projects	**(Other) Existing Applications**	**(Other) Existing Infrastructure components**
New Project Proposals (depend on)	[1] For Shared resources Shared benefits	[2]For Shared resources Inputs (Application outputs)	[3]For Shared resources Inputs (Infrastructure outputs)
Existing Application (depends on)	[4] For Risk Reduction Reduced cost Benefit increase	[5] For Shared resources Inputs (application outputs)	[6]For Shared resources Inputs (infrastructure outputs)
Existing Infrastructure (depends on)	[7]For Risk Reduction Cost Reduction Benefit Increase	[8] For Shared resources	[9] For Shared Resources Inputs

Table 3. A comparison of different types of portfolio management

Topic	Description	Page #
Asset classes	FPM: Different types of stocks, and bonds NPD and R&D: Projects ITPM: Projects, applications and infrastructure components	69
Management Model	FPM: Groups of specialists manage different types of assets (stocks, bonds etc.). NPD: Managed by multi-functional teams R&D: Managed by specialists ITPM: Specialized groups manage different types of assets (applications, projects, and infrastructure) with some overlap. Other business departments have different degrees of involvement depending on how IT governance is implemented.	69
Strategic Alignment	All four types of portfolio management (FPM, NPD, R&D, ITPM) emphasize the need to align the portfolio with long-term goals or organizational strategies	70
Process Change Impact	FPM, NPD and R&D typically focus on a few products or processes. ITPM investments relate to a variety of processes or products depending on project and application portfolios (sometimes involve the entire organization—enterprise wide system)	70

c. Finally, relationships between different types of decisions (involving individual as well as portfolios) were iteratively developed through discussions between multiple researchers, and constant comparison with relationships discussed in the literature. For example, identifying new projects based on the health of a portfolio (relationship between Step 5 and Decision 7 in Figure 3) is discussed in Weill and Vitale (1999).

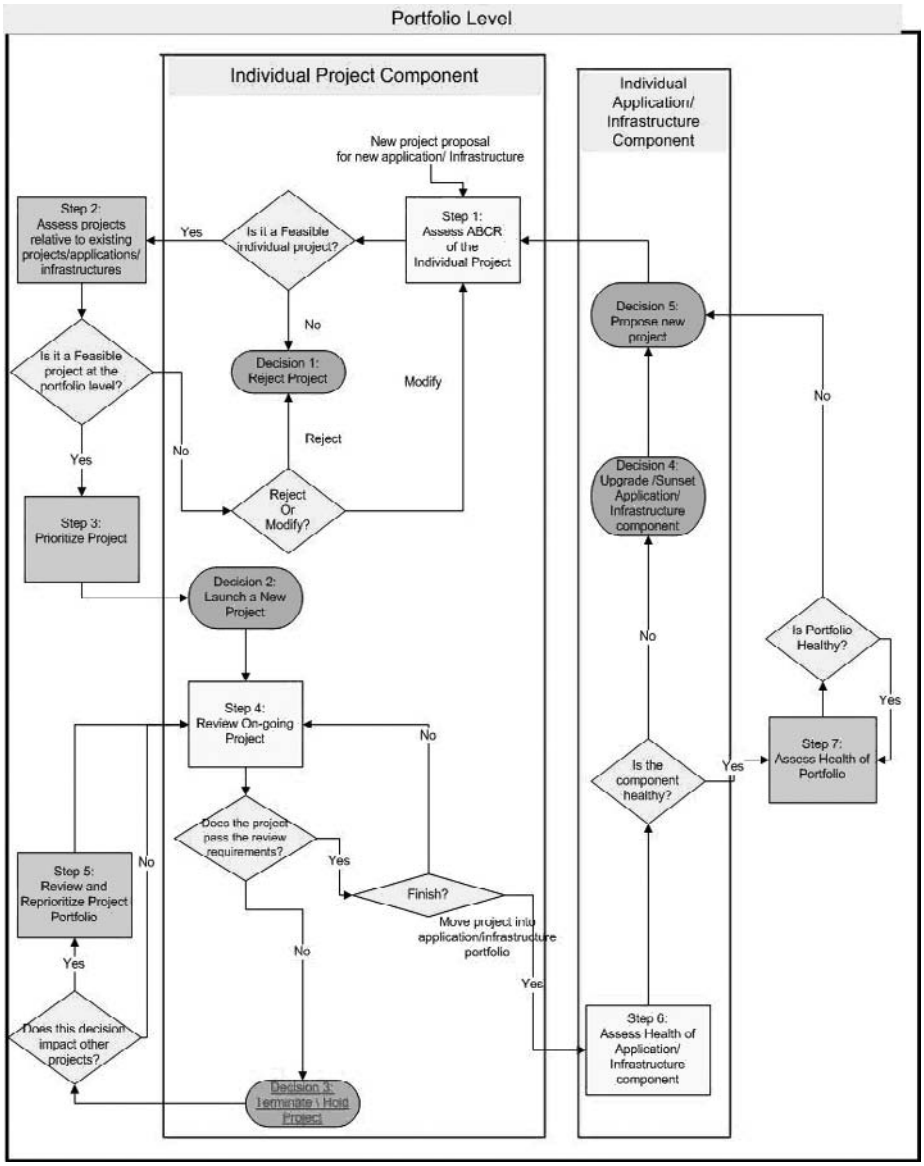
The following discussion also summarizes ideas from NPD, R&D, and MIS research that are relevant to each of the steps. The ITPM process consists of a series of interrelated steps. One or more steps could result in major ITPM decisions. The ITPM process consists of steps and decisions that pertain to *individual project components* of the portfolio (Step 1, Step 4, Decisions 1-3), steps and decisions that pertain to *individual application or infrastructure components* (Step 6, Decision 4), and steps and decisions that pertain to *the IT portfolio* (steps 2,3,5,7, and Decision 5). *While some of the steps in the framework are well-known, the combination of steps and decisions presented in Figure 2 represents a holistic process-oriented view of ITPM that is likely to be of value to researchers as well as managers.*

Step1: Assess Alignment, Benefit, Cost, and Risk (ABCR) of Individual Projects

Ideas for IT projects[2] could be generated in multiple ways, depending on how IT governance is implemented (Weill, 2004). Sources of project ideas include the SISP process, business users, and IT personnel. A variety of approaches for evaluating individual projects have been proposed in the NPD, R&D, and MIS literature. These include traditional financial evaluation techniques, such as net present value, newer financial evaluation techniques, such as real options (Benaroch & Kauffman, 1999; Santos, 1991), the balanced scorecard (Martinsons, Davison, & Tse, 1999), as well as other techniques (Ross & Beath, 2002).

Traditional financial evaluation methods typically consider benefits and costs, but often

Figure 3. A framework for understanding major steps and decisions in ITPM



underestimate the value of projects (Benaroch & Kauffman, 1999). Newer financial evaluation methods, such as real options, capture managerial flexibility in investment decisions (Benaroch & Kauffman, 1999), as well as uncertainty in cash flows (risk). However, parameter estimation is difficult. Scoring models or balanced scorecards can be used to capture strategic benefits (Martinsons et al., 1999). There is scope for additional research on newer and better methods of evaluating individual IT projects. It is important to note that feasibility in the context of the framework depends on the specific organization, and could be a combination of economic, technical, operational, legal, and ethical factors.

Step 2: Assess Project Fit Relative to Existing Applications/Infrastructures

Projects that are feasible in Step 1 need to be examined, relative to an organization's existing IT portfolio components (project, application, and infrastructure components). This type of analysis is best done by a committee made up of individuals from different business and IT units (ITPM Committee). In this step, organizations may reject or request modification of project proposals. Reasons for project modification or rejection could include similarity with existing IT portfolio components (redundancy), incompatibility with infrastructure standards, incompatibility with existing portfolio components, improved alignment with existing IT portfolio, and other actions that could enhance alignment, or benefit or reduce cost or risk of the IT portfolio. The committee may need to consider a variety of interdependencies between the proposed project and the existing IT portfolio (Table 2) and decide that the original project justification needs to be modified, since the individuals proposing the project were not aware of all the interdependencies. For example, the proposed project could have synergies with existing ITP components, thus reducing project cost and making the project more attractive. If, for example, a new portal project requires a Web infrastructure that is missing from the infrastructure subportfolio, then the project might be rejected or postponed until the infrastructure is acquired through a new project proposal. This step could be complicated and could benefit from additional research.

Step 3: Prioritize Projects

Feasible projects can be prioritized using single criteria methods, based on a financial calculation, or using multiple criteria methods. Project prioritization has been extensively researched, and a variety of approaches have been proposed in the MIS, NPD, and R&D literature (Chien, 2002; Cooper et al., 1997; Dickinson, et al., 2001; Liberatore & Stylianou, 1995a; Liberatore & Stylianou, 1995b; Stummer & Heidenberger, 2003). These include scoring models, analytical hierarchy process, expert systems, mathematical programming, and hybrid methods that do not consider project interdependencies. More sophisticated methods consider interdependencies between projects. The R&D and NPD literature contains several approaches that consider interdependencies (Dickinson et al., 2001; Stummer & Heidenberger, 2003). Research on interdependent project selection and ranking in the MIS literature is limited. Santhanam and Krypakis (1996) propose a nonlinear programming model that considers resource, benefit, and technical interdependencies between projects. Bardhan and Sougstad (2004) present a dynamic programming model that considers hard and soft project dependencies in prioritizing projects. There is considerable scope for additional research that examines the applicability of approaches proposed in the context of R&D or NPD to IT projects, and further development of other methods that consider project interdependencies. In addition to modeling-oriented research, qualitative research that illustrates different types of interdependencies and how to manage them (Verma & Sinha, 2002) will be useful.

Step 4: Review On-Going (Individual) Projects

Projects which pass individual and portfolio-level examination will be accepted and moved to the implementation phase. Projects need to be actively managed to ensure results that are measured in terms of process and product outcomes (Wallace & Keil, 2004; Wallace et al., 2004a; Wallace et al., 2004b). IT projects are considered particularly

difficult to manage, and there is an extensive body of literature on IT project management (Wallace & Keil, 2004; Wallace et al., 2004). Similar streams of research exist in the areas of R&D project management and NPD project management (Nobeoka & Cusumano, 1995; Santiago & Bifano, 2005). Termination of ongoing projects is often difficult, due to factors such as escalation of commitment (Keil, 1995; Keil & Mann, 1997; Keil, Truex, & Mixon, 1995). A study of methods to deescalate commitment to failing projects (Keil & Robey, 1999; Montealegre & Keil, 2000) is an interesting research area.

Step 5: Review and Reprioritize Projects in the Portfolio

Business changes, technology changes, and a variety of project risks (Schmidt et al., 2002) result in projects being delayed, terminated, or refocused. Such changes impact other projects, as well as resource availability. IT managers are, therefore, faced with the need to rebalance their portfolio of projects dynamically (in relation to changes in some projects in the portfolio). While there is considerable research on individual IT projects, rebalancing IT portfolios in response to changes in individual projects is an underdeveloped research area. This step is similar to Step 3, in terms of evaluating interdependencies between projects. However, there are likely to be several resource reallocation decisions involved in addition to reprioritizing projects. These resource reallocation decisions should be based on a systematic analysis of the status of existing projects and possible new projects. However, such systematic analysis could be extremely complex. Also, since IT impacts almost every business process, unlike R&D and NPD, there are likely to be a larger number of IT projects, and a greater need for project reprioritization. Hence, IT portfolios are similar to financial portfolios with actively traded assets and a large number of buy and sell transactions due to—or in anticipation of—market changes. In actively traded financial portfolios, managers must frequently make decisions about reallocation of financial resources generated by sell transactions. In IT portfolios, managers must frequently make decisions about reallocation of resources as a result of cancelled, delayed, or refocused IT projects. However, the number and types of resources and their interdependencies involved in IT portfolio reprioritizations are likely to be greater than in the case of financial portfolios. Project reprioritization in MIS is an underresearched area that lends itself to modeling, as well as empirical studies.

Step 6: Assess the Health of Application/Infrastructure Components

Completed projects result in applications or infrastructure components or systems. An application or infrastructure component could be considered unhealthy, because it is not aligned with organizational goals, does not produce significant organizational benefits, is too expensive to maintain, too risky, or due to a combination of these factors. The MIS literature emphasizes the fact that systems resulting from completed projects may not be used as originally planned. There is extensive literature on IT adoption and use (Jasperson, Carte, Saunders, Butler, Croes, & Zheng, 2002; Jasperson et al., 2005; Venkatesh et al., 2003) and IT success (DeLone & McLean, 2003). System use problems can be provided by system users or technical support personnel through periodic surveys and/or analysis of technical support calls. It is important to have processes in place to systematically analyze the health of applications or infrastructure components. MIS literature in this area is limited. Weill and Vitale (1999) illustrate the use of risk return bubble diagrams to analyze the health of an application portfolio. Interesting research issues in this area include defining health of applications and infrastructure components, and

designing processes and metrics to assess health. Validation and extension of existing models of adoption and use is relevant to this step.

Step 7: Assess the Health of Portfolio and Balance

Assessing health of the IT portfolio considers different types of interdependencies in analyzing ABCR of the portfolio (unlike Step 2, which only considers dependencies involving a proposed project). Table 4 illustrates how different types of dependencies apply to different steps in the ITPM framework. For example, project-project (PP), project-application (PA), and project-infrastructure (PI) dependencies are relevant during Steps 2 and 5.

This step is closely related to SISP (Grover & Segars, 2005). Approaches such as critical success factors or value chain analysis can be used as part of the assessment. However, SISP methodologies often focus on alignment and benefits, and do not integrate cost and risk. There is an increasing emphasis on the risk of an organization's IT portfolio as a result of increased organizational dependence on IT, and increased likelihood of security attacks. Issues such as threat assessment, disaster recovery planning, and regulatory compliance are part of this step. Organizational performance and increasing emphasis on the business value of IT (Carr, 2003) could drive projects to reduce the cost of the IT portfolio.

Managers may be interested in knowing what the total support costs of the portfolio are, which applications are the most expensive to support, which are the most risky applications are, or what the risk-return characteristics of applications are, or what the major risks of the portfolio are, and how they can be mitigated as part of ITP balancing. Additional research which guides balancing decisions is required.

The results of portfolio health assessment could be portfolio balancing decisions to upgrade or sunset applications or other types of projects. It is important to realize that unlike IT portfolios, where assets can be disposed of relatively easily, there is significant cost associated with implementing IT portfolio balancing decisions. Besides hardware and software costs, such balancing decisions could include costs of personnel reassignment and training. There is considerable scope for additional research on integrated approaches to assessing the health of an IT portfolio and balancing the portfolio based on health assessment. Such approaches should consider alignment, benefits, costs, and interdependencies.

Table 4. Dependencies during different steps in the ITPM framework

	P	A	I
P	Step 2,5	Step 2,5	Step 2,5
A	Step 7	Step 7	Step 7
I	Step 7		Step 7

P: Project; A: Application; I: Infrastructure

ILLUSTRATIVE EXAMPLE

This section provides a brief example to illustrate how managers might use the ITPM Decision Framework in Figure 3. DigiBank is a major financial institution. The CEO and CIO of the organization have seen some articles about ITPM, and believe they could benefit from better managing their IT assets through ITPM. DigiBank has some processes in place for managing IT assets. However, the CEO and CIO believe there is considerable scope for more systematic management of IT assets. They are unsure about what constitutes ITPM, how it is different from what they are doing now, and what is involved in implementing ITPM.

Figure 3 presents a process which the CIO or (other managers) can use to systematically question existing IT management processes, identify strengths and weaknesses in existing processes and put in place additional processes needed to implement ITPM.

The process (Figure 3) starts with ensuring that each project that is proposed has a measure of alignment, costs, benefits, and risks (Step 1). The CIO realizes that Digibank has some processes for measuring project costs and benefits. Processes for measuring project risk exist, but need improvement. Processes for measuring project alignment need to be created. The discussion and references in Section 4 provide a starting point for improving project risk and alignment measurement.

On reviewing Steps 2 and 3 the CIO realizes the need to improve processes for comparing all proposed projects. They initiate a review of existing processes relating to these steps. The references relating to Steps 2 and 3 provide a starting point for fresh ideas. The CIO believes Digbank has good processes for project review (Step 4). However, decisions for project termination are not always consistent and could be improved, as is the case for reviewing and reprioritizing a portfolio of projects (Step 5). Digibank has a checklist and processes for Step 6. However, the CIO feels that decision making regarding upgrading or sunsetting a project could be improved. There are no processes in place for assessing the health of a portfolio of applications (Step 7) and references in Section 4, such as (Weill & Vitale, 1999) are a good starting point.

Having completed this exercise, the CIO of DigiBank feels that without Figure 3, systematic review of key steps and decisions needed to implement ITPM would have been considerably more difficult and would not have considered all the steps and decisions. Such a systematic review helps organizations assess their existing processes, relative to decisions and processes required for ITPM, and help them plan for ITPM implementations.

MANAGERIAL ISSUES

Practitioner articles regarding ITPM (Leliveld & Jeffery, 2003; Maizlish & Handler, 2005) mention that several organizations have implemented ITPM to varying degrees (maturity levels). Weill and Aral (2006) suggest that ITPM is a best practice. Surveys of chief information officers (Leliveld & Jeffery, 2003) regarding ITPM implementation reveal several managerial issues and challenges in implementing ITPM. Some interesting managerial issues for which related MIS literature in other implementation contexts exists are discussed below.

Management Support and IT Governance

ITPM projects are enterprise projects, because they involve multiple departments in addition to IT. Even within IT, there are likely to be different stakeholder groups, such as project managers, application support personnel, architects, and administration personnel with access to cost and contracting responsibilities involved in an ITPM project. Also, ITPM projects can be perceived as IT projects and not business projects. While benefits to IT from a successful ITPM implementation may be expected, business units may be unclear as to why they should support an ITPM project. Successful ITPM projects are likely to require senior management or CXO (CEO, CFO, COO, and CIO) level support in order to resolve conflicts and ensure project success. Hence, the role of senior management and how they demonstrate support for ITPM is an interesting area of research. Prior research has recognized that power structures within an organization influence the type of senior management support required (Jasperson et al., 2002). How ITPM fits within an overall IT Governance framework, and roles and responsibilities of personnel involved in ITPM, is an interesting research area. This could build upon existing MIS literature on senior management support, and IT governance in other contexts (Brown & Grant, 2005; Peterson, 2004; Rau, 2004; Weill & Ross, 2005).

Relationship Between IT and Business

Successful ITPM projects are likely to involve significant interaction between IT and business. These interactions are likely to occur during ITPM implementation as well as during ongoing management of the IT portfolio. Hence, recognizing differences between IT and business (Bassellier & Benbasat, 2004; Keil, Tiwana, & Bush, 2002; Peppard, 2001) and improving trust (Bushell, 2004; Gefen, 2004) are likely to be important in ensuring success of ITPM implementations. It is important to note that different stakeholders (e.g., business units, IT subunits) in an ITPM implementation may prefer outcomes (in terms of project selection or prioritization) that are best for them, while successful ITPM implementation is aimed at decisions that are best for the organization as a whole. This is likely to lead to conflicts between subunits. Hence, issues of power and politics are also likely to be important (Davenport, Eccles, & Prusak, 1992; Hart & Saunders, 1997; Jasperson et al., 2002) for a variety of portfolio management decisions. Power and politics are also extremely important, because successful ITPM implementation requires sharing a variety of data across departmental boundaries. Examples of such data include cost data, contract clauses, application and infrastructure performance data, and project risk and success data.

Organizational Readiness and Change Management

Successful ITPM implementation in organizations could change several IT-related decision making processes in organizations. Examples of such processes include strategic planning, budgeting, project management processes, risk management processes, and application support processes. Hence, implementing ITPM can be viewed as business process change (Kettinger & Grover, 1995). Organizations differ significantly in their readiness to change (Guha, Groven, Kettinger, & Teng,

Table 5. Summary of directions for future research

#	Directions for future ITPM Research	Page #
1	Methods of specifying the values of portfolio components	71-72
2	Improved methods of assigning shared costs of infrastructure to applications and users	72
3	Studies of risk management in IT from an integrated perspective and examines the relationships between project, application, and infrastructure risks	73
4	Qualitative and quantitative research on characterization and management of different types of interdependencies between different types of IT assets	74-75
5	Newer and better methods of evaluating the feasibility of individual IT projects	77
6	Additional research on methods to deescalate commitment to failing projects.	78
7	How to rebalance IT project portfolios in response to changes in individual projects.	78
8	Validation and extension of models of IT adoption and use	79
9	Comprehensive health assessment of IT assets	79
10	How ITPM fits within an overall IT Governance framework and roles and responsibilities of personnel involved in ITPM	80-81
11	The role of senior management in supporting ITPM	81
12	Issues of power and politics in ITPM decisions	81
13	Case studies of ITPM implementations	81

1997) and successful ITPM implementations are likely to involve active change management.

While a variety of research approaches are useful in studying managerial issues related to ITPM, case studies of ITPM implementations would be a particularly interesting and valuable area of future research. Such case studies would help to better understand "how" and "why" issues related to ITPM implementation (Yin, 1994).

CONCLUSION

The concept of managing IT as a portfolio of assets is gaining momentum, and is beginning to be considered a best practice (Jeffery & Leliveld, 2004). However, an analysis of what an IT portfolio is, how it is related to other types of portfolios, and how it should be managed is underdeveloped in MIS research. This article represents an attempt to present a cumulative body of relevant knowledge to aid future development of ITPM.

This article makes several contributions. First, it compares ITPM with other types of portfolio management, and develops an improved understanding of IT assets and their characteristics. A review of relevant literature from multiple disciplines is used to develop an improved understanding of ITPM concepts, such as assets, alignment, costs, benefits, risks, and interdependencies. Second, it presents a systematic, process-oriented framework for understanding ITPM. The proposed framework identifies critical ITPM decision stages. This framework could be of use to practitioners of ITPM who are interested in effective ITPM implementations in organizations, as well as researchers who are interested in further theoretical development of ITPM. An illustrative example of the use of this framework is provided. Third, the article integrates ideas from other types of portfolio management, as well as different streams of MIS research into ITPM decisions and management of ITPM implementations. This integration of research streams helps to identify a cumulative body of ITPM-related knowledge that exists and facilitates further development of ITPM. Several ideas for future ITPM research (summarized in Table 5) are identified.

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ENDNOTES

[1] Our discussion of asset classes and sub-portfolios (projects, applications, infrastructure components) is different from that of Broadbent and Weill (1998) who classify IT investments as infrastructure, transactional, informational, or strategic. Our approach is analogous to classifying financial portfolios as consisting of stock, bond and cash assets or sub-portfolios. Broadbent and Weill's approach is similar to classifying financial portfolios as conservative, balanced, and aggressive. Both approaches to classifying portfolios are used.

[2] A project proposal can be a request to build a new application/infrastructure component or an upgrade request for a current infrastructure/application component.

[3] This research was funded in-part by a grant from the Belk College of Business UNC-Charlotte.

This work was previously published in Information Resources Management Journal, Vol. 21, Issue 3, edited by M. Khosrow-Pour, pp. 64-87, copyright 2008 by IGI Publishing (an imprint of IGI Global).

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